

## Perceived Muscle Soreness in Recreational Female Runners

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### ABSTRACT

*Int J Exerc Sci* 3(3): 108-116, 2010. The purpose of this study was to determine if rating of perceived exertion correlated with perceived muscle soreness during delayed onset muscle soreness (DOMS) in female runners. This study examined the pre and post running economy measures and perceived muscle soreness before and after a 30-min downhill run (DHR) at - 15% grade and 70% of the subjects predetermined maximum oxygen uptake (VO<sub>2</sub> peak). Six female recreational runners (mean age = 24.5) performed level running at 65%, 75%, and 85% of their VO<sub>2</sub> peak prior to DHR (baseline economy runs), as well as, immediately following and 4 successive days after the DHR. Results: Subjective response related to perceived muscle soreness increased significantly from a mean of 2 (pre DHR) to 62 (2 days post DHR) on a scale of 1-100. Creatine kinase levels and oxygen consumption increased post DHR compared to pre DHR. Rating of perceived exertion did not change between the economy runs performed prior to or at any point after the DHR. Conclusion: Perceived muscle soreness is a better tool than the RPE scale to monitor exercise intensity for recreational female runners during periods of DOMS and running economy is adversely affected by DOMS.

KEY WORDS: delayed onset muscle soreness, overuse injury, muscle strain, overtraining, recovery

### INTRODUCTION

Delayed Onset Muscle Soreness (DOMS) affects elite athletes, recreational athletes, and beginner exercise enthusiasts. Distance runners who are especially exposed to downhill grades are seldom confronted with muscle soreness that appears approximately 48 hours after the run. It's important to recognize the symptoms of DOMS and form an understanding on how its presence influences training programs to help maintain a progressive and safe running routine. Beginning exercise enthusiasts most likely will initially experience muscle soreness secondary to unaccustomed stress to muscle and connective tissues, while elite and recreational athletes can experience DOMS

upon commencing seasonal training, as well as, high intensity bouts of training or competition. Due to the growing popularity of recreational running events it's important to identify the affects of muscle soreness on participants, especially female runners since they are more prone to knee injury upon fatigue of the quadriceps muscles. Classified as a type I muscle strain, DOMS presents with tenderness or stiffness to palpation and/or movement (Gulick and Kimura, 1996; Safran, Seber, and Garrett, 1989). Discomfort from DOMS can range from slight muscle stiffness to severe debilitating pain (Cheung, Hume, and Maxwell, 2003). The aim of this study was to investigate the usefulness of a perceived muscle soreness scale as an adjunct to the commonly used Rating of

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Perceived Exertion (RPE) scale to monitor muscle soreness and actual muscle damage in recreational female runners.

Downhill running produces a heavy eccentric load on the quadriceps muscles as they brace the forward momentum related to running on a downward grade, and it's been shown that eccentric muscular activity can produce severe muscle pain as opposed to concentric work which did not elicit muscle soreness 48 hours post exercise (Croisier, Camus, Forthomme, Maquet, Vanderthommen, and Crielaard, 2003). Serum creatine kinase (CK) concentration has been widely used to estimate the amount of muscle damage induced by exercise. (Ebbeling & Clarkson, 1989). Anti-inflammatory mediators congregating to the site of muscle tissue damage is triggered by the accumulation of cellular debris and further amplified by proteases, phospholipases, and active oxygen species (Croisier, et al., 2003). Since the sarcolemma swelling ultimately leads to breakdown on the membrane and release of enzymes from the intracellular space CK and other proteins will transfer to plasma, and the accumulation of muscle tissue damage inhibitory chemical substances leads to intracellular pressure, thus inducing afferent stimuli leading to pain at the local region (Croisier, et al., 2003).

Training involving endurance running has been regulated by the RPE scale during high intensity efforts or long distance training since this measurement tool is commonly used to qualify overall feeling of exertion. Rating of perceived exertion is a convenient way to measure overall exertion when other physiological measures such as Maximum Oxygen consumption (VO<sub>2</sub> peak), lactate, and Heart Rate (HR) are not

easily attainable. In order to validate the RPE scale as a training tool the association between RPE, HR, and lactate has been examined (Green, McLester, Crews, Wickwire, Pritchett, and Lomax, 2006). Heart rates have shown to be variable during different periods of a training cycle due to overtraining or improved fitness, and therefore RPE has been substituted as a method for exercise intensity prescription (Glass, Knowlton, and Becque, 1992). However, Green et al. identified that a relationship between HR, lactate, and RPE has been shown to be weak in different workloads and training intensities, leading us to examine another method of monitoring feedback during training, especially during muscle soreness (2006).

Certain situations during the training cycle can require specific tools for symptomatic response to exercise, thus perceived muscle soreness is undeniably an important symptom requiring attention when experienced by runners. Unique forms of exercise predisposing the elite or recreational athlete requires more work to fully understand the utility of the RPE scale as a descriptive tool for relating perceptual and physiological variables (Green, et al, 2006). Investigating the validity of RPE during periods of DOMS provides meaningful information for coaches and athletes to use during training prescription, but more studies will help identify the usefulness of RPE as a guide for exercise intensity during a variety of symptomatic events and training intensities, especially when muscle soreness is present. Prescription of exercise, recovery, and training intensity necessitates consideration for proper use of feedback from the athletes and the need for consideration of

monitoring muscle soreness in addition to RPE.

Female distance runners' injuries need to be vigorously investigated due to the high incidence of lower limb pathology. Studies imply female runners depend on the quadriceps as well as the anterior cruciate ligament antagonists in responding to anterior tibial translation (Arendt, 1996). Female runners categorized as recreational to elite amateur are training for endurance events in growing numbers since there is an increasing emergence of non-collegiate and non-professional competitions. Many female runners and their coaches may try to "work through" the pain associated with DOMS, but the perception of pain should take a role in assessing the training routine while helping decrease the probability of injury secondary to decreased quadriceps functioning. This study may possibly determine the need to acquaint the female runner with muscle soreness and demonstrate why perceived muscle soreness should be used as an assessment tool instead of, or as an adjunct to, a RPE scale during episodes of DOMS. Prescription of exercise intensity and recovery should consider a more specific assessment of the athlete versus a general measure of overall perceived exertion. Consequently, it could be possible that DOMS might affect the rating of perceived muscle soreness more than a rating of overall perceived exertion.

### **METHODS**

#### *Subjects*

Six recreational female distance runners (all undergraduate college students) that responded to an advertisement on the campus regarding this study volunteered

and completed the study. Participants in the study had no previous competitive running experience and ran between 3 and 7 hours per week. To be considered for participation in this study, the subjects were to have no history of lower limb injury or other medical condition that would be exacerbated by performing any portion of tests required throughout the course of this study.

#### *Initial Screening and Instructions*

All individuals were required to sign an informed consent approved by University of Central Missouri's Institutional Review Board. All subjects were provided instructions during participation of study including; 1) no medications including anti-inflammatory meds and pain meds, 2) no ice, ultrasound, electrical stimulation, massage, or other treatments, 3) no training and/or exercise during length of study, however participants were allowed limited walking on campus for classes and normal low level physical activities job related. 4) no resistance training involving lower extremities, 5) no caffeine the day of testing (sodas, coffee, etc), 6) eat breakfast at least two hours prior to testing, 7) remain hydrated throughout duration of study, and 8) don't change diet during the length of the study. No regard for the subject's menstrual cycle was made for the duration of the study.

#### *Descriptive Measurements*

Personal parameters including the study's population age ranged from 21-31 y with a mean age of  $24.5 \pm 3.5$  y. Height, body mass, and body composition were ( $170 \pm 6.6$  cm.,  $63.6 \pm 9.2$  kg, and  $22 \pm 3.2$  % respectively). Peak oxygen uptake (VO<sub>2</sub> peak) and HR was measured with a Parvo Medics gas analyzer (model True one; Salt

Lake City, UT), and a Trackmaster treadmill (model TMX 420). Subjects mean VO<sub>2</sub> peak measured  $2.78 \pm 0.25$  L·min<sup>-1</sup>. Subjects performed a VO<sub>2</sub> peak test with a 5-min mild warm-up at a brisk walking pace on treadmill while becoming familiar with headgear and mouthpiece. Test began at  $6.44$  km·h<sup>-1</sup> and increased  $1.61$  km·h<sup>-1</sup> every 2-min. Subjects ran on the treadmill until three of four criteria were met; RER > 1.15, RPE > 17, VO<sub>2</sub> plateau, and HR within 11 bpm of predicted maximum.

### *Submaximal VO<sub>2</sub> peak / Running Economy Determination*

Subjects warmed-up on a treadmill for 5-min at  $6.44$  km·h<sup>-1</sup>. Determination of subjects running speed was performed on level surface at 65%, 75%, and 85% of predetermined VO<sub>2</sub> peak, which was based on initial VO<sub>2</sub> peak test. Subjects ran for 5 minutes during each stage with 5 minutes rest between stages. The test was performed twice, two days and four days post VO<sub>2</sub> peak test. The second test was used to confirm running speeds correlating to 65%, 75%, and 85% of predetermined VO<sub>2</sub> peak.

Mean treadmill speeds were  $7.7 \pm 0.2$ ,  $9.0 \pm 0.3$ ,  $10.1 \pm 0.2$  km·h<sup>-1</sup> respectively for 65%, 75%, and 85% VO<sub>2</sub> peak. Mean values were collected for VO<sub>2</sub>, HR, VE, RER, and RPE. The standard Borg perceived exertion scale was used for measuring RPE. Mean values were measured during last 30-sec of each 5-min stage. Subjects performed the same economy run protocol as before downhill run immediately following and four successive days after Down Hill Running. Mean values for VO<sub>2</sub>, HR, Minute Ventilation (VE), Respiratory Exchange Ratio (RER), and RPE were collected for comparison to pre-DHR economy test.

### *Downhill Running*

To elicit muscle soreness subjects performed a downhill run for a total of 30-min on a treadmill set at -15% grade (Chen, Nosaka, and Tu, 2007). After 5-min of warm-up on a level treadmill at  $6.44$  km·h<sup>-1</sup> the subjects began the downhill running (DHR). Gas analysis was measured to identify the subject's 70% of VO<sub>2</sub> peak during the first 5-min. After an initial 5-min period the speed was held constant and gas analysis discontinued when the goal VO<sub>2</sub> peak was reached with mean speed at VO<sub>2</sub> peak measuring  $11.6 \pm 0.7$  km·h<sup>-1</sup> and  $1.94 \pm 0.2$  L·min<sup>-1</sup>.

### *Indicators of Muscle Damage*

This study measured markers of muscle damage including perceived muscle soreness and creatine kinase levels. Perceived muscle soreness and CK levels were measured at baseline, prior to DHR, and before economy run each day after DHR. Perceived muscle soreness was ranked on a 100 point analog scale, 0 = "no soreness", 25 = "mild pain", 50 = "moderate pain", 75 = "severe pain" and 100 = "the worst pain you can imagine". The goal of this "new" pain scale was to attempt to better quantify those areas between the typical 1-10 pain scale so that pain would be more exactly represented. Subjects stepped up and down from a 40 cm box four times immediately before performing each day's run (Chen, Nosaka, and Tu, 2007). Subjects then were asked to provide a number relating to the perceived soreness of the leg muscles using the 100-point scale.

### *Blood Collection*

Blood draws were done by trained personnel from the antecubital vein by

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standard venipuncture and centrifuged for 10-min to obtain plasma. Plasma samples were stored and frozen at -20° C for later CK analysis by the local hospital laboratory.

## Statistical Analysis

Pre and post DHR markers of muscle damage (perceived muscle soreness and creatine kinase), specific parameters related to running economy (VO<sub>2</sub> and RPE) were measured and statistically analyzed by one-way repeated measures analysis of variance. Tukey's post hoc test was conducted to identify where differences occurred. Statistical significance was set at P < 0.05.

Changes Post-Downhill Running		Pre DHR	Immed.	1 Day	2 Day	3 Day	4 Day
VO <sub>2</sub> peak (L/min)	65%	1.8 ± .24	1.99* ± .23	1.93 ± .29	1.83 ± .22	1.75 ± .22	1.74 ± .21
	75%	2.1 ± .25	2.19* ± .24	2.13 ± .31	2.06 ± .28	2.02 ± .30	2.02 ± .27
	85%	2.27 ± .25	2.35 ± .27	2.34 ± .32	2.34 ± .28	2.26 ± .31	2.29 ± .30
CK (ml/dl)		105 ± 51	195 ± 172	892* ± 666	476 ± 368	375 ± 341	566 ± 583
	Perceived Muscle Soreness	2.17 ± 4	30.33 ± 31	51.17* ± 30	62.17* ± 28	36.17* ± 23	20.5 ± 16
RPE	65%	9.17 ± 2.2	11.08 ± 3.5	10.59 ± 2.8	10.97 ± 3.1	10.17 ± 2.1	10.08 ± 2.3
	75%	11.75 ± 2.3	12.52 ± 3.5	12.33 ± 2.8	12.58 ± 3.1	12.17 ± 2.5	11.5 ± 2.4
	85%	13.67 ± 3.0	14.17 ± 3.5	13.75 ± 2.8	14.00 ± 3.0	13.67 ± 2.6	13.17 ± 2.9

Table 1: Mean values, (\*) indicates significant difference from pre value (P < 0.05).

## RESULTS

### Rating of Perceived Exertion

Rating of overall perceived exertion was measured during the economy runs; pre DHR, immediately after completion of

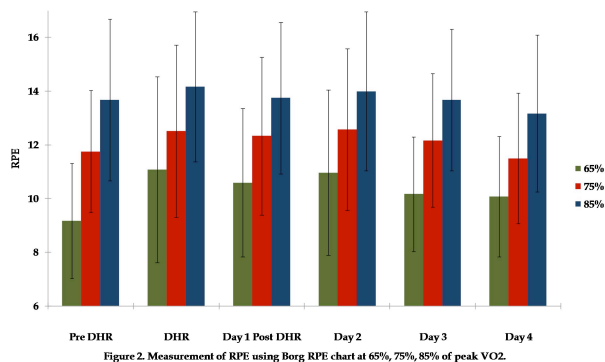


Figure 2. Measurement of RPE using Borg RPE chart at 65%, 75%, 85% of peak VO<sub>2</sub>.

DHR, and each economy run 4 successive days post DHR (P<0.05). Figure 2 indicates economy runs that were performed at 65%, 75%, and 85% of peak VO<sub>2</sub> with RPE measured during the last 30 seconds of each stage.

### Creatine Kinase

Plasma creatine kinase levels were measured before DHR, immediately after DHR, and prior to each economy run during the 4 successive days post DHR (P<0.05). Figure III shows creatine kinase

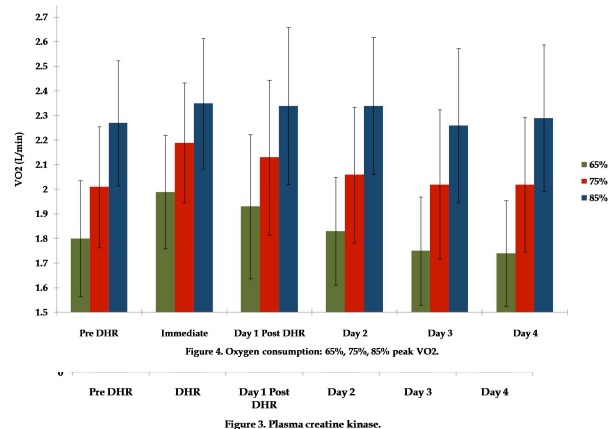


Figure 3. Plasma creatine kinase.

levels increased nine-fold 24-h after DHR and remained elevated at 4 days post DHR (P<0.05).

### Running Economy

The magnitude of change in VO<sub>2</sub> was greatest immediately after DHR, and gradually returned close to baseline by 4 days post DHR (P<0.05).

## DISCUSSION

The presence of DOMS can occur in recreational female runners as they begin their training or partake in high intensity efforts when the muscles are stretched in the eccentric mode with load, increasing the risk for DOMS (Schutte and Lambert, 2001). Recreational runners should understand

the implications of continuing to work through the pain associated with DOMS due to some deciding to train through the discomfort, while their RPE remains at a self-perceived “normal” level. Understanding the implication of muscle soreness and resulting adverse effects will help recreational runners guide their training\recovery cycles properly.

Self-perceived rating of muscle soreness can be a useful tool in preventing DOMS as well as alleviating the discomfort associated with muscle tissue damage in distance runners of all skill levels. Other studies have explored a number of treatment methods for DOMS, however Hume, Cheung, Maxwell, and Weerapong (2004) state prevention is the best “cure”. Realizing muscle soreness is a separate etiological event than RPE can serve as a defense mechanism from adverse affects associated with DOMS so awareness of perceived muscle soreness can warrant a rest\recovery cycle when RPE still remains at its usual level for the same intensity. Creating exercise and training programs in a way that decreases the chance for pain and discomfort derived from DOMS may help maintain the integrity and consistency of the routine. Nosaka, Sakamoto, and Newton (2001) noted that DOMS can be reduced with a protective prior single bout of exercise even at 50% of maximal voluntary contraction. Recreational female runners may benefit from active recovery at low intensity to help decrease the pain associated with muscle soreness due to heavy training loads. Building progressive intensity and recovery into training programs can help reduce the symptoms associated with DOMS and prevent the related pain. However, when pain and discomfort appears, recreational runners

should know how to gauge their training and recovery accordingly so the use of a perceived muscle soreness scale may help preserve their training schedule while possibly continuing advancement of their fitness levels.

Power is a measurement of the amount of work that can be performed in a unit of time, so when one looks at absolute VO<sub>2</sub> peak (L\min), work corresponds to amount of oxygen consumed in a given amount of time. This study indicates that more work is required to expend the same aerobic power output even though the RPE remained similar to baseline. Peak oxygen consumption increased 2 to 11% above baseline while RPE didn't show significant changes between tests on different days. When taking the above aspects into consideration athletes must allow for recovery during times of muscle soreness after bouts of high intensity work or in the presence of overtraining syndrome even if the perceived exertion seems normal. Trying to train during periods of muscle soreness will likely be detrimental to performance since less power will be produced as indicated in this study showing diminished peak measurement of oxygen uptake (aerobic power) while RPE stays the same, but perceived muscle soreness increases dramatically.

Muscle cell damage derived from downhill running and other high intensity training is seen as a precipitating factor for DOMS. Integrity of the sarcolemma is likely disrupted and this cellular disturbance produces mitochondrial swelling along with muscle damage caused by degenerating muscle followed by the release of CK due to destruction of the muscle tissue contractile components (McArdle, Katch, Katch, 2007). Uusitalo

(2001) indicated that overtraining can produce skeletal muscle cell dystrophy creating DOMS, so it's possible that the important rebuilding phase will be challenged if too much physical stress damages the performance gains of the athlete.

Creatine kinase activity increased rapidly with a peak at one-day post-DHR, accompanied by muscle tissue damage resulting in an inflammatory response. Swelling follows the inflammatory reaction creating increased pressure in the tissue compartment (Bobbert, Hollander, & Huiging, 1986; Friden, Sfikianos, & Hargens, 1986; Howell, Chila, Ford, David, & Gates, 1985). Contraction or palpation of muscles instigates increased muscle compartment pressure while inciting afferent pain receptors (Smith, 1990). Substances creating the swelling and pain activate a high degree of perceived muscle soreness 2 days post eccentric action during down hill running indicated by this study while CK level was at it's highest after 24 hours. It's apparent the intracellular space has inflamed to a point that causes afferent pain stimulus, thus producing the latent perceived soreness 24 hours following peak CK level.

To our knowledge no other study has compared RPE and perceived muscle soreness to running economy (VO<sub>2</sub>) and an indicator of muscle damage (creatin kinase) in female runners while using a downhill running protocol. The lack of change in RPE during the post DHR's indicates female recreational runners involved in this study don't report an increase in overall fatigue even though they experience significant muscle soreness. Due to limited success of promoting force

production or managing swelling after muscle damage athletes should be encouraged to reduce their activity following intense exercise inducing DOMS (Hume, et al., 2004). An imbalance between the stress of training and recovery over an extended amount of time can lead to a decrease in performance (Barnett, 2006). Female recreational athletes may resist exerting caution when not experiencing increased fatigue based on their RPE while simultaneously being subjected to muscle soreness. Muscle damage may originate from a single bout of intense exercise or a high volume of training, leading to the benefit for using a rating of perceived muscle soreness by coaches, trainers, and athletes while gauging runners recovery cycle, ultimately aiding in overall performance.

The current study noted an increased VO<sub>2</sub> peak cost of running post DHR, while perceived muscle soreness in lower extremities was prominent enough to correspond to an increase in oxygen consumed at same workload. Mechanical elements including stride length, stride rate, vertical force production, and activation of leg extensor muscles can influence running economy measures (Saunders, Pyne, Telford, Hawley, 2004). But, muscle soreness can create a "guarding" affect causing less efficient running. Thus, biomechanical alterations in running due to muscle soreness will then cause an increase in oxygen uptake for the same amount of work performed as observed in this study. Change in VO<sub>2</sub> peak can be attributed to the alteration in running kinematics caused by muscle soreness after downhill running at a 15% grade (Chen, Nosaka, & Tu, 2007).

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Further investigation of DOMS can help identify effective strategies for exercise training in a variety of populations with the most evident being both genders while comparing female to male recreational runners. Monitoring the perception of pain can help provide assistance in decreasing the chance of muscle strain, muscle pull, or connective tissue damage. Increasing number of older adults are engaging in amateur running events and training programs while many are “weekend warriors” who participate in high intensity efforts. Exposing the aging muscle to high intensity or large volume without previous progression can lead to DOMS and increase likelihood for injury.

### LIMITATIONS

The current study was limited to recreational female runners but needs to include more participants with the addition of a control for menstrual cycle included. The addition of males and college or professionally trained athletes might also be of interest for understanding the possibility of using a DOMS scale as an adjunct to the RPE chart for exercise prescription.

Future research may include a focus on the reliability and validity of using a 100 point analog scale to represent muscle pain and with higher number of subjects using regression analysis to correlate the pain scale with Borg RPE scale.

In summary, there was virtually no change in RPE while seeing great changes in the DOMS scale lending support for the inclusion of the DOMS scale to be used as an adjunct to the RPE when prescribing exercise during times of high intensity training. Perceived muscle soreness warns an athlete that physiological mechanisms

are transpiring causing the need for rest or possible active recovery. Using an RPE scale, as a measurement of RPE, may not serve as the best tool to allow rebuilding of the affected muscle tissue versus paying attention to perceived muscle soreness. Therefore the importance of utilizing perceived muscle soreness to prescribe exercise intensity is paramount. More studies on DOMS relating to both genders and elite athletes are needed to clearly identify the importance for using a rating of perceived muscle soreness scale rather than, or as adjunct to the use of overall RPE while referring to symptoms of training.

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