©Journal of Sports Science and Medicine (2004) **3,** 70-75
http://www.jssm.org

Research article

REDUCED MUSCLE PAIN INTENSITY RATING DURING REPEATED CYCLING TRIALS

Peter S. Micalos ✉, Frank E. Marino and Derek Kay

School of Human Movement Studies, Charles Sturt University, Bathurst, Australia

Received: 16 January 2004 / Accepted: 20 February 2004 / Published (online): 01 June 2004

ABSTRACT
The purpose of this study was to investigate muscle pain intensity rating using a 10-point category-ratio pain intensity scale during self-paced cycling exercise within three trials. Eleven subjects (age 21.4 ± 2.6 years; VO_2 peak 3.3 ± 0.9 L·min^{-1}) performed a 60-min cycling trial on three occasions. During each trial subjects cycled at the utmost work intensity for 60-min. To simulate competitive training, 1-min maximal effort sprints were performed every 10-mins into the trial. Ambient temperature and relative humidity were set at 33 ± 0.7 °C and 63 ± 2.0%, respectively. During exercise, subjects ranked the muscle pain intensity at 5 min intervals and following each sprint effort. Simple main effects revealed that muscle pain intensity ratings were significantly lower in trial 3 compared with trial 1 at the 50 min [F = 4.5(2 30); p = 0.015, eta^2 = 0.05], 55 min [F = 4.89(2, 30); p = 0.011; eta^2 = 0.05], and 60 min [F = 3.6(2, 30); p = 0.034; eta^2 = 0.04] time interval. Repeated measures ANOVA revealed a significant increase in the mean distance cycled amongst the trials (p < 0001). These results indicate an attenuation in muscle pain intensity rating with endurance exercise training when performed over three trials. The reduced pain intensity rating may be due to adjustments in cadence and gear selection amongst the trials.

KEY WORDS: Pain, intensity, training, rating, cycling.

INTRODUCTION

The experience of pain and discomfort during intense exercise is well recognised however there is a surprising deficit of research in this area. Investigations into pain during physical exertion were first published in the 1960's when Caldwell and Smith (1966) reported on pain intensity during an isometric endurance task. In a study by Lloyd (1972) subjects rated the pain during an isometric muscle contraction from just 'noticeable pain' to 'intolerable pain' between 10 and 50 seconds into contraction. In a recent study by Cook et al. (1997) pain was assessed during a ramped cycle ergometry test to exhaustion. The study found that the rating of leg muscle pain increased as a positively accelerating function of relative exercise intensity. Furthermore, the total pain index reported by subjects following the exercise test elicited greater sensory and affective variables compared to pain stimuli typically used in experimental settings (Cook et al., 1997).

Several methods have been applied to quantify the individual sensation of pain. Tools such as the category ratio scale can be applied to assess pain intensity during the performance of dynamic exercise (O'Connor and Cook, 1999). The administration of category ratio (CR) scales in measuring pain has been shown to be valid and reliable. In research by Cook et al. (1997), a CR scale was developed by combining the verbal anchors from the Pain Perception Profile (Tursky et al., 1982) with features of the easily administered 0 – 10 CR Borg scale (Borg, 1990). The 0 – 10 CR Pain Intensity scale was found to be a valid and reliable tool in assessing pain intensity and peak pain values during physical exercise (Cook et al., 1997).

The number of investigations in pain response with exercise training are limited. In a study by Scott and Gisbers (1981), tolerance to ischaemic pain in competitive swimmers was found to differ with the training status of the athletes. The study noted that changes in pain tolerance during the training season indicated a short-term adaptation to pain as a result of systematic exposure to brief periods of intense exercise. In a study by Egan (1987), it was suggested that training for specific sports may desensitise athletes to pain.

Few studies have reported on the rating of muscle pain intensity during vigorous and enduring physical exercise and there is an absence of research determining muscle pain intensity rating during self-paced exercise training trials. Therefore the purpose of this study was to assess muscle pain intensity rating during the performance of self-paced cycling exercise amongst three repeated trials.

METHODS

Subjects

Eleven cyclists (eight men, three women) with a range of cycling abilities were recruited for the study. All participants were apparently healthy, having completed a health history questionnaire. The participants were physically active individuals and were familiar with cycling exercise and the performance of intense physical activity for extended periods. The study was conducted with the approval of the Charles Sturt University Ethics in Human Research Committee and all subjects signed a letter of informed consent.

Descriptive measurements and peak oxygen uptake ($VO_{2\ peak}$) were obtained during a familiarisation session before participating in three repeated cycling trials. For determining body fat, skinfold measurements were collected from triceps and subscapular in duplicate using skinfold callipers (British Indicators Ltd, England). The percent bodyfat was determined using the method described by McArdle et al (1991). Standing height was measured to the nearest 0.1 centimetre using a precision stadiometer (Len Blaydon, Lugarno, Australia) while body mass was measured to the nearest 10g using an electronic precision balance (HW-100KAI, GEC, Avery Ltd, Australia). The participants diets were not monitored or restricted however they were requested to abstain from the consumption of alcohol, caffeine and tobacco for 24 hours prior to each trial. Subjects were requested to perform the same type of physical activity for the duration of the study and to refrain from heavy physical exercise on the day prior to the time trial.

The $VO_{2\ peak}$ was determined by an incremental test with the subjects own bicycle mounted to an electromagnetic trainer (Tacx, Technische Industrie Tacx BV, Wassenaar, Netherlands). Subjects performed the test in mild temperature conditions (22-24 ^{o}C; humidity 40-50%). During the test subjects breathed through a two-way non-re-breathing valve (series 2700 large, Hans Rudolph, St Louis, MO, USA). Expired air was sampled by an automated gas analyser (Quinton Instrument Company, Bothel, WA, USA). Before each test the pneumotach (Hans Rudolph, St Louis, MO, USA) and gas analysers were calibrated using a 3 L syringe and gases of known concentration, respectively. Expired air passed through a mixing chamber of 5.5 L volume and was sampled at 30 s intervals. Following a brief low intensity warm up, the incremental test commenced at a workload of 100 W and increased by 10 W at 30 s intervals until the subject could not maintain the required workload. Subjects were required to remain in a seated position during the test. The highest VO_2 that could be maintained for one minute was deemed to be the $VO_{2\ peak}$.

Exercise training protocol

Subjects were required to complete three cycling time trials in warm humid conditions. The aim was to cycle the greatest distance possible within the allotted 60 minutes, adjusting pedalling speed and gear ratio as required. A higher temperature and humidity were established to simulate intense training conditions during cycling in a warmer climate and to determine the exercise protocol reliability, as previously published (Marino et al., 2002). The temperature and humidity was set at 33 ± 0.7^{o}C and 63 ± 2.0%, respectively. Trials were separated by at least 5 days to avoid partial heat acclimation through the trials, and within 14 days. A fan providing a constant wind speed of 2 ms^{-1} was positioned directly in front of the subject. Subjects were allowed to drink water *ad libitum* throughout each trial.

The trial was performed by subjects using their own bicycle mounted to an electromagnetic cycle trainer. The cumulative distance cycled and the power output was recorded at 5 minute intervals. The distance travelled and power output was recorded from the digital display unit connected to the cycle trainer. The cycle trainer was calibrated for distance accuracy before each trial by recording the pedal revolutions required to cycle 5 km. This procedure yielded a coefficient of variation of 0.7%. During each trial, subjects were permitted to alter gear ratio and cadence as required. This procedure provided a self-selected exercise intensity, as is often performed during exercise training.

In order to provide an additional measure of performance and to simulate intense training conditions, subjects were also required to perform 60 seconds of maximal effort ‘sprint’ exertions every 10 minutes into the trial. During the non-sprint phases, subjects could return to a self-selected cycling intensity. Subjects were provided with on-going performance results including elapsed time, heart rate, and a time count leading into each sprint effort.

Pain Intensity data collection

During each cycling trial, a category ratio pain intensity scale with verbal anchors was displayed in front of the subject for viewing during exercise. The scale was numbered 0 - 10. The verbal anchors and numerical vales for the scale are as follows; 0 no pain at all, ½ very faint pain, 1 weak pain, 2 mild pain, 3 moderate pain, 4 somewhat strong pain, 5 strong pain, 7 very strong pain, 10 extremely intense pain (almost unbearable). Subjects were instructed to view the scale and apply it to rank the intensity of pain in the thigh muscles at each moment of report during cycling exercise. The verbal ranking of the pain intensity was acquired every 5 minutes into the trial. The pain rating for the sprint phases were obtained immediately after each sprint effort. The ratings at 10, 20, 30, 40, 50, 60 min represent the pain intensity during the sprint phases of the trial. The ratings at 5, 15, 25, 35, 45, 55 min represent pain intensity for the non-sprint phases during self-paced exercise.

Statistics

The data for pain intensity were analysed by a 2-way repeated measures ANOVA (TIME x TRIAL). Significant interactions were analysed by simple main effects and Tukey's HSD post-hoc procedure was used where appropriate. When appropriate, the eta^2 was used as a measure of the magnitude of association among variables. Rough estimates for the strength of association for a given eta^2 value are that 0.01 is considered a small effect, 0.09 medium, and 0.15 large. The data for cycling distance were analysed by 1-way repeated measures ANOVA for trial. The data for power output were measured by 2-way ANOVA (TIME x TRIAL). All data are presented as mean ± SD and the level of significance was set at $p < 0.05$.

RESULTS

Descriptive characteristics of subjects

The mean age of the subjects was 21.4 ± 2.6 years, height 176.3 ± 10.8 cm, weight 74.9 ± 10.0 kg, body fat % 14.2 ± 5.0, VO_2 peak 3.3 ± 0.9 $L·min^{-1}$, peak power output 322.8 ± 86.3 watts.

Muscle Pain Intensity ratings during three cycling trials

The muscle pain intensity ratings during the three cycling trials are presented in figure 1. There was a significant main effect for exercise time [$F = 118(2, 30)$; $p < 0.001$; $eta^2 = 0.54$], indicating a significant increase in muscle pain intensity rating during exercise. There was a significant exercise time by trial interaction [$F = 6.3(2, 30)$; $p = 0.005$; $eta^2 < 0.01$]. Post hoc comparisons revealed that muscle pain intensity ratings were significantly lower in the

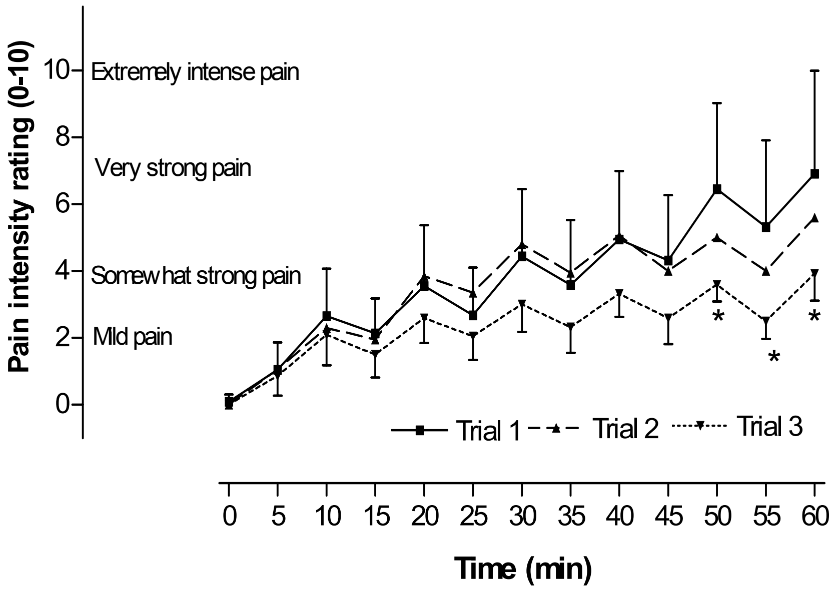

Figure 1. Pain intensity ratings during cycling exercise for three repeated trials. The values at the 10, 20, 30, 40, 50, 60 min intervals represent the pain intensity rating for the sprint phases. The non-sprint pain intensity ratings are 5, 15, 25, 35, 45, 55 min. * Significant differences from trial 1.

third trial compared with trial 1 at the 50 min [F = 4.5(2, 30); p = 0.015, eta^2 = 0.05], 55 min [F = 4.89(2, 30); p = 0.011; eta^2 = 0.05], and 60 min [F = 3.6(2, 30); p = 0.034; eta^2 = 0.04] time interval.

Cycling performance in three cycling trials

Repeated measures ANOVA revealed a significant increase in the mean distance cycled amongst the trials (F = 14.163(2, 32); p < 0001; eta^2 = 0.01). The mean distance cycled for trials 1, 2 and 3 were 26.3 ± 5.0, 27.7 ± 5.7 and 28.1 ± 5.6 km, respectively. The distance cycled in trial 1 was significantly different from trial 2 (p < 0.01) and 3 (p < 0.001). The mean power output for trial 1, 2 and 3 were 229 ± 48, 241 ± 74, 224 ± 53 W, respectively. There was no main effect for power output by exercise time (F = 1.9; p = 0.176) or exercise time by trial interaction (F = 1.9(2, 30); p = 0.161).

DISCUSSION

The main finding in the present study was that muscle pain intensity rating decreased over the three endurance cycling trials during exercise. The rating of muscle pain intensity was significantly attenuated in the final stages of the third trial. Vecchiet and Galletti (1979) reveal that a reduction in the intensity of the sensation or an increase in the latency to onset or, an increase in the level of the workload at which pain appears for the first time are apparent with training. Several studies on pain have assessed pain ratings in the acute post-exercise phase by assessing pressure pain threshold (Koltyn et al., 1996; Perrsson et al., 2000). Previous research reveals that pressure pain responses are also effected by exercise training (Scott and Gijbers, 1981). In a study by Waling et al. (2000), pressure pain responses were significantly reduced in groups that performed strength and endurance training over ten weeks. However, the present results indicate that there is a reduction in the rating of muscle pain during cycling exercise with repeated trials. This is in contrast to research by O'Brien and O'Connor (2000), showing a consistent muscle pain intensity rating with repeated trials. The contrast in results may be associated with differences in the exercise duration. The exercise duration in the present study was 40 min longer than the study by O'Brien and O'Connor (2000), and significant differences in pain rating in the present study were revealed in the later stages of the third trial.

Muscle pain rating during exercise has been shown to positively accelerate with the relative leg power output and oxygen consumption during ramped cycle ergometry (Cook et al., 1997). This suggests that the rating of muscle pain intensity is associated with exercise work intensity. However, the present results reveal a diminution in muscle pain rating between trials with no significant difference in leg power output. Although the power output remained consistent, there was a significant increase in cycling distance covered between trials. It would be expected that an increase in distance performance would also result in an increase in power output. The disparity in results may be associated with the measurement procedure. The present study applied a flexible work intensity protocol which permits the subject to modify gear ratio, cadence and power output during exercise, as is often performed during training. This allowed for dynamic variations in power output within each exercise trial. Moreover, the measurement of power output was recorded at the moment of report and the distance covered was a continuous cumulative measure over the time trial. The disparity between power output and cycling distance could be minimised with more frequent recording of power output during exercise. Other limitations within the present study may have also effected the results to some extent. The small sample of subjects, absence of monitoring the intake of substances such as caffeine (Motl et al., 2003) or medications, and the limited supervision of the subjects training schedule apart from the trials, could have effected the outcome. Subjects were briefly informed to maintain their regular training schedule and to abstain from caffeine and heavy exercise 24 h prior to each trial. However, the present data indicate that with endurance cycling trials there is a reduction in muscle pain intensity rating despite a significant increase in the cycling distance performance.

It is possible that the reduced pain rating in the present study may be associated with a training induced hypoalgesia. However, previous research indicates that alterations in cycling cadence (pedalling frequency) can significantly effect muscle pain intensity rating (Jameson and Ring, 2000). Local sensations such as muscle and knee pain during cycling exercise are increased at lower cadences for similar power output. This is probably associated with an increase in muscle force production required at lower cadences. The variable intensity protocol in the present study permitted subjects to alter the cadence by changing the pedalling frequency and gear ratio throughout each trial. Since our participants were not competitive cyclists and presented a significant increase in cycling distance performance over the trials. It is probable that adjustments in cadence and gear selection (anecdotal observations) improved the cycling distance performance and reduced the intensity of muscle pain amongst the trials.

CONCLUSIONS

The present study provides evidence that the rating of muscle pain intensity during exercise is attenuated with endurance cycling training. Furthermore, the attenuation in muscle pain intensity with training is apparent despite an increase in cycling distance performance. The decline in muscle pain rating and increased cycling performance maybe associated with adjustments in cadence and gear selection amongst the endurance trials.

ACKNOWLEDGMENTS

The assistance of Nathan Serwach, Matthew Hilder, and Jack Cannon in facilitating the collection and recording of data is gratefully acknowledged.

REFERENCES

Borg, G. (1990) Psychophysical scaling with applications in physical work and the perception of exertion. *Scandinavian Journal of Work Environment and Health* **16,** 55-58.

Caldwell, L.S. and Smith, R.P. (1966) Pain and endurance of isometric muscle contractions. *Journal of Engineering Psychology* **5,** 25-32.

Cook, D.B., O'Connor, P.J., Eubanks, S.A., Smith, J.C. and Lee, M. (1997) Naturally occurring muscle pain during exercise: assessment and experimental evidence. *Medicine and Science in Sports and Exercise* **29,** 999-1012.

Egan, S. (1987) Acute-pain tolerance among athletes. *Canadian Journal of Sport Science* **12,** 175-178.

Jameson, C. and Ring, C. (2000) Contributions of local and central sensations to the perception of exertion during cycling: Effects of work rate and cadence. *Journal of Sports Sciences* **18,** 291-298.

Koltyn, K.F., Garvin, A.W., Gardiner, R.L. and Nelson, T.F. (1996) Perception of pain following aerobic exercise. *Medicine and Science in Sports and Exercise* **28,** 1418-1421.

Lloyd, A.J. (1972) Auditory EMG feedback during a sustained submaximal isometric contraction. *Research Quarterly* **43,** 39-46.

Marino, F.E., Kay, D., Cannon, J., Serwach, N. and Hilder, M. (2002) A reproducible and variable intensity cycling performance protocol for warm conditions. *Journal of Science and Medicine in Sport* **5,** 31-43.

McArdle, W.D., Katch, F.I. and Katch, V.L. (1991) *Exercise Physiology.* Lea & Febiger, Philadelphia.

Motl, R.W., O'Connor, P.J. and Dishman, R.K. (2003) Effect of caffeine on perceptions of leg muscle pain during moderate intensity cycling exercise. *The Journal of Pain* **4,** 316-321.

O'Brien, P.M. and O'Connor, P.J. (2000) Effect of bright light on cycling performance. *Medicine and Science in Sports and Exercise* **32,** 439-447.

O'Connor, P.J. and Cook, D.B. (1999) Exercise and pain: the neurobiology, measurement, and laboratory study of pain in relation to exercise in humans. *Exercise and Sport Sciences Reviews* **27,** 119-66.

Persson, A.L., Hansson, G.-Å., Kalliomäki, J., Moritz, U. and Sjölund, B.H. (2000) Pressure pain thresholds and electromyographically defined muscular fatigue induced by a muscular endurance test in normal women. *The Clinical Journal of Pain* **16,** 155-163.

Scott, V. and Gijbers, K. (1981) Pain perception in competitive swimmers. *British Medical Journal* **283,** 91-93.

Tursky, B., Jammer, L.D. and Friedman, R. (1982) The pain perception profile: a psychophysical approach in the assessment of pain report. *Behavior Therapy* **13,** 376-394.

Vecchiet, L. and Galletti, R. (1979) Muscular pain under effort. In: *First International Congress on Sports Medicine Applied to Football.* Vol 1. Rome. Ed: L. Vecchiet and D. Guanella. pp. 39-50.

Waling, K., Sundelin, G., Ahlgren, C. and Järvholm, B. (2000) Perceived pain before and after three exercise program - a controlled clinical trial of woman with work-related trapezius myalgia. *Pain* **85,** 201-207.

KEY POINTS

- Muscle pain intensity rating was significantly reduced with three repeated cycling endurance trials.
- Attenuation in muscle pain intensity rating appeared at 50, 55, 60 mins into exercise within the third trial.
- The attenuation in muscle pain intensity with training is apparent despite an increase in cycling distance performance.
- The decline in muscle pain rating and increased cycling performance may be associated with adjustment in cadence and gear selection amongst the endurance trails.

AUTHORS BIOGRAPHY

Peter S. MICALOS
Employment
Lecturer, School of Human Movement, Charles Sturt University, Bathurst, Australia
Degree
MEd
Research interests
Exercise induced analgesia
Email: pmicalos@csu.edu.au

Frank E. MARINO
Degree
Associate Professor
Research interests
Physiological and neurological responses to exercise in hot and cool conditions
Email: fmarino@csu.edu.au

Derek KAY
Degree
PhD
Research interests
Physiological and neurological responses to exercise in the heat and the effects of hydration status.
Email: dkay@csu.edu.au

✉ **Peter Micalos**
Charles Sturt University, School of Human Movement Studies, Bathurst NSW 2795, Australia