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Acute recovery from exercise in people with multiple sclerosis: A pilot exploratory study on the effect of exercise intensity.

Abstract

Purpose

A better understanding of how people with Multiple Sclerosis (pwMS) recover from exercise may help inform **interventions**.

Methods

We explored physiological and perceptual responses following exercise of different intensities, using a crossover exposure-response design, in 14 adults with MS and nine controls. A cycling exercise test determined maximum capacity (W_{peak}).

Participants then performed 20minute exercise sessions relative to W_{peak} (random order separated by 7days): 1) 45% and 2) 60% continuous cycling, and 3) 90% intermittent cycling (30seconds cycling, 30seconds rest). During a 45minute recovery period, tympanic temperature ($Temp^{\circ}C$), exertion in breathing (RPE_{br}) and legs (RPE_{leg}), and cortical excitability (MEP_{area}) were measured.

Results

Eleven pwMS and eight controls completed the study. Controls performed better on the exercise test ($p < 0.05$), thus more absolute work during subsequent sessions.

PwMS took longer to recover RPE_{leg} with recovery time increasing with intensity (45%-6mins; 60%-15mins; 90%-35mins) and correlating with $Temp^{\circ}C$. MEP_{area}

was significantly depressed in both groups at 45% and 60% ($p < 0.001$), in the MS group; this also correlated with RPE_{leg}.

Conclusion

Feelings of leg exertion **may persist after exercise in** some pwMS, especially at high intensities. This may relate to body temperature and, after continuous exercise, cortical excitability. **These results support considering the recovery period post exercise and provide insight into potential correlates of post exercise fatigue**

Introduction

Multiple sclerosis (MS) is an inflammatory disease and the most common chronic neurological condition effecting young adults worldwide [1]. It is characterized by focal areas of demyelination in the central nervous system and a disease course that is variable in both presentation of symptoms and progression. The evidence for the beneficial effects of exercise for people with MS (pwMS) is compelling. Systematic reviews demonstrate that exercise improves aerobic fitness, muscle power and mobility-related activities and indicate that mood, fatigue, and health-related quality of life may also benefit [2-4]. In addition pragmatic interventions have shown that delivery of exercise can be cost effective [5]. However, questions remain over appropriate exercise intensities that both optimise benefits and are tolerable and sustainable [6-8].

Fatigue is a chronic, pervasive and disabling symptom [9, 10] reported to affect mobility and participation in work, and social activities in the majority of pwMS [11]. The underlying mechanism causing this chronic fatigue in MS is a complex phenomenon with both central and peripheral components implicated [10, 12-16]. Fatigue symptoms can be both physical and cognitive and include feelings of exhaustion, a lack of energy, low motivation and physical tiredness [17, 18]. PwMS often report low levels of energy and overwhelming feelings of fatigue after participating in physical activity [7].

The physiological responses during exercise **result in symptoms of exertion perceived by the individual. The relationship between the severity of the perceived exertional symptoms and physiological responses is well described, with level of perceived exertion increasing with exercise intensity** [19]. These

exertional symptoms **are** perceived **both** during and after exercise **and** affect enjoyment of **and participation in** physical activities. Specifically individuals moderate and reduce exercise intensity depending on symptoms of respiratory distress and leg fatigue or tiredness [20]. Recent evidence suggests that pwMS have a normal through exercise response, in both physiological and perceptual measures, but have an altered perceptual response in recovery with higher levels of leg fatigue perceived after maximal exercise [7]. Furthermore pwMS with higher levels of chronic fatigue have been observed to have a greater increase in perception of leg fatigue after maximal exercise [7] and for some individuals elevations in core temperature induced by exercise may further exacerbate these symptoms [21]. Therefore, recovery from exercise may be an important consideration for prescribing tolerable and sustainable exercise programs in this group. Indeed the results from a randomised trial of exercise intensities found that the high intensity intermittent intervention arm was less well tolerated in terms of attendance at sessions and withdrawing from the intervention [6].

Transcranial Magnetic Stimulation (TMS) is a non-invasive technique used to examine the excitability of the corticospinal -neuromuscular pathway. TMS produces a repetitive discharge of motor neurons and the subsequent size of the motor evoked potential (MEP) have been used to provide markers of central drive alongside perceptual measures of fatigue following repetitive muscle activation in MS [22]. Thus, TMS may provide neurophysiological correlates of exertion following exercise and provide insight into mechanisms of post exercise fatigue.

A better understanding of how pwMS recover following exercise may inform exercise prescription that is both effective and well tolerated. The purpose of this study was to therefore explore the physiological, **neurophysiological** and perceptual responses following exercise of different intensities in pwMS.

Methods

Design

A crossover exposure-response study of 3 x single exposures (randomised order) in pwMS, with a **comparison control group without MS**

Participants

Fourteen people with confirmed MS and nine control participants of similar age and gender were recruited. Participants with MS were referred through neurologists at the xxxxxx xxxxxx or recruited through regional and local MS Society branches. To be included pwMS had to have (1) Clinically definite MS, (2) be age of 18 years old or older (3) have adequate mental capacity to consent, (4) be in a relatively stable phase of their illness (not within two weeks of any sudden change/relapse) and (5) able to use a cycle ergometer. A control group, of similar age and gender were recruited by word of mouth. Individuals for both groups were excluded if they had (1) any neurological (other than MS in MS group) or psychiatric conditions (2), a neurosurgical procedure, a heart pacemaker, medication pump or surgical clips (3) or an absolute contraindication to maximal exercise testing.

The study was approved by the National Research Ethics Service, (XX/XXXXXX/XX). Participants gave written informed consent and the study was conducted in accordance with the Declaration of Helsinki.

The study was carried out at the xxxxxxxx, xxxxxx or at xxxxx xxxxxx xxxxxx. The assessments were carried out by the same investigators between 1200 and 1500hrs in a quiet physiology laboratory maintained at standard room temperature (~21°C). Prior to all sessions participants were requested not to participate in strenuous physical exercise during the previous 24 hours and asked to refrain from the consumption of caffeine, alcohol or cigarettes for a period of at least 2 hours before attending.

Procedures

Exercise test

At the first session subjects performed exercise test to volitional exhaustion on a cycle ergometer (Monark 874E Vansbro, Sweden) to determine peak work rate (W_{peak}). On arrival, co-pathologies, treatment history and medications were documented. This information alongside the pre-participation physical activity questionnaire (PAR-Q) [23] and blood pressure (BP) measurements were used to screen for precautions and contra-indications to exercise. Participants completed the physical activity scale for the elderly (PASE) [24], the Barthel Index (10 item 0-20 scale, higher score indicates less disability) [25], the Subjective Vitality Scale (6 item, 7 level likert scale, averaged higher score indicates more vitality) [26] and the Fatigue Severity Scale (9 item, 7 level likert scale, averaged higher score indicates more fatigue) (FSS) [27]. Participants were familiarised with Borg's ratings of perceived exertion (RPE) CR10 scale for breathing (RPRbr) and legs (RPEleg) [28] and height (m), and weight (kg) were **measured wearing minimum clothing (seca measurement systems, London, UK)** .

Participant were seated up-right of the cycle ergometer with handlebars adjusted for personal comfort, saddle heights adjusted to accommodate partial flexion of the knee **at the end of the down stroke of the pedal**. Feet were secured in the pedals by straps. The test started with unloaded cycling, participants were asked to maintain 50 revolutions per minute (rpm), if the participant could not achieve 50rpm they were encouraged to cycle as fast as they could (not less than 40rpm). Every 2min the external load on the cycle ergometer was increased by 0.5kg, equating to 25watts at 50rpm. The test was terminated when the participant reached volitional exhaustion or their cadence dropped by 10rpm. The W_{peak} (watts) was recorded to determine exercise intensities in subsequent sessions.

Intensity sessions

Participants attended 3 further sessions set 7 to 14 days apart. Each session consisted of 20min exercise on the cycle ergometer at intensity relative to W_{peak} . The sequence of the sessions was in a random order allocated at enrolment, neither participants nor assessors were blinded. Intensities were (1) 45% W_{peak} continuous cycling at 50rpm (45%), (2) 60% W_{peak} continuous cycling at 50rpm (60%) and (3) 90% W_{peak} intermittent cycling, 30sec cycling 30sec rest, cycling at 50rpm (90%). Therefore the same total amount of work was performed during the 45% and 90% session, to enabled comparison of intensity without the co-founder of total work. The 60% session requires a third more total work and also represents an intensity shown to be effective in training programs [4].

Initially participants completed the Subjective Vitality Scale, they then lay semi-supine on examination plinth positioned so that their upper bodies were angled to

30° of an up-right position. Heart rate (HR) (Polar Vantage, UK), tympanic temperature (Temp°C) (thermoscan, Braun, Germany), RPEbr for and RPElegs data (Borg CR10 RPE scale) and Motor Evoked Potentials (MEPs) from of Transcranial Magnetic Stimulation (TMS) was collected every 5min for 20min to establish baseline.

After the baseline measures individuals moved to the cycle ergometer, **with saddle and handle bar settings configured as per the exercise** test, situated within 1 metre of the examination plinth. Exercise started with unloaded cycling at 50 rpm for 1min. Resistance was applied to the bike according to the intensity under investigation and timing commenced. Participants received verbal encouragement to maintain 50 rpm and HR, RPEbre and RPElegs recorded every two minutes.

Immediately following the exercise participants alighted from the cycle-ergometer and returned to the examination plinth where HR, Temp°C and RPEbr, RPEleg and MEPs were recorded at 30 seconds and every 2min until 10min and then at 5min intervals until 45min post exercise (35mins for MEPs). The day after each session participants were telephoned and completed the Subjective Vitality Scale and asked if they had any adverse reactions to the exercise.

TMS protocol

The TMS protocol followed that of Meaney et al [29], which has demonstrated reliability in pwMS. Briefly, single pulse TMS to the motor cortex was applied using a Bistim² (Magstim Company, United Kingdom). Stimuli were delivered in blocks of 5 with a delay of 7-10 s between each. MEPs were recorded from the tibialis anterior

(TA) on the less affected side of the body. Paired surface electrodes (T3404, Thought Technology Ltd, Canada) were positioned 20mm apart over the belly of the muscle, parallel to, and just lateral to the medial shaft of the tibia, in line with its longitudinal contour. Locations were carefully noted **to insure correct** placement during the next visit. The reference electrode was attached at the olecranon process.

The stimulators were set to discharge a single pulse from a double, cone shaped coil (110mm). Initial exploration determined the “hotspot” (optimal stimulation location) for the TA. The coil was placed on the head parallel to, and ~ 0.5-1.5 cm lateral to the mid-line (nasion to inion), with its mid-point aligned antero-posteriorly. A 60% maximum output stimulus was applied around the location until the ‘hotspot’ was identified. The coil position was maintained throughout the experiment by aligning it to indelible ink pen marks on the scalp.

The motor threshold (MT) (the lowest TMS intensity necessary to evoke MEPs in the target muscle) was determined by starting stimulation at 60% of maximal output and in 5% increments until the stimulus disappeared. The output was then increased in 1% increments until threshold was reached. MT was the intensity that elicited MEPs with amplitudes of $> 50\mu\text{V}$ in at least 5 of 10 stimuli from the relaxed TA. The experiment was conducted at 120-130% of MT.

Data was analysed using Signal v.3.11 (Cambridge Electronic Design, UK). MEPs were full wave- rectified and areas calculated as the product of the mean amplitude (mV) and the duration (ms). The average of each block was calculated after

discarding the first stimulus [29]. Post-exercise MEPs were normalised relative to pre-exercise values [30].

Statistical analysis

Statistical analysis was performed in SPSS v 19.0 (IBM Corporation, USA). For a participant to be included in the statistical analysis all 3 sessions had to be completed. Missing data due to a missed measurement point during an assessment was treated as missing by random and multiple imputations (5 imputations for each data point) were used. Independent samples t-test was used to determine differences between MS and Control groups in participant descriptive and exercise test parameters. Repeated measures ANOVA was used to assess difference between MS groups and control group at each exercise intensity. Repeated measures ANOVA was also used to assessed difference between exercise intensities for the MS group. Simple contrast against first (baseline) were used to determine when data increased and returned to baseline values. Pearson's correlations were used to investigate the association between perceived exertion and physiological measures. Alpha was set at $p < 0.05$.

Results

Of the **16 pwMS initially screened two did not take part in the study (uncontrolled hypertension, no longer interested)** and three failed to complete all three sessions (*1 person 60% and 90% sessions, 1 person 45% session, and 1 person 45% and 60% sessions*). One control group participant also failed to complete all sessions (*60% session*). **Reasons given for not completing sessions were family or other time commitments and unable to tolerate TMS.** Therefore, 11 pwMS and eight controls were included in the analysis; descriptive data are reported in table 1. Group composition was similar for sex, age, height and weight. However, the control group were significantly more active ($p = 0.002$).

Insert Table 1 about here

The peak measures obtained from the exercise tests are displayed in table 2. The control group performed significantly better on the exercise test achieving greater W_{peak} ($p=0.019$) eliciting a greater HR ($p=0.036$) and breathing RPE ($p=0.025$). However, perceived exertion in the legs did not differ between groups ($p = 0.218$).

Insert Table 2 about here

Figure 1 shows the HR response to exercise and during recovery. Repeated measure ANOVA revealed a significant effect of the exercise on HR for all intensities ($p<0.001$). There was no overall significant difference between groups ($p>0.05$) for any intensity. However, following 45% the MS group recovered slower than the control group (*MS 15min, Control 4min*). Following 60% neither group recovered to resting HR within the 45min recovery measurement period and following 90% both groups HR returned to resting 30min post exercise.

Insert Figure 1 about here

Figure 2 shows illustrates the significant effect of exercise on RPE_{leg} and RPE_{Br} for all intensities ($p < 0.001$). There was no significant difference between groups ($p > 0.05$) for any intensity for either RPE legs or breathing. However, in the MS group RPE took longer to recover, with the length of time taken for RPE_{leg} to recover increasing with intensity.

Insert Figure 2 about here

MEPs were significantly depressed after exercise for both groups at 45% and 60% ($p < 0.001$) but only the control group at 90%. Both groups had returned to baseline at 15mins at 45%. At 60% the MS group returned to baseline at 15mins and the control group at 25mins. There was no significant differences in MEPs between groups or between exercise intensities in either group ($p > 0.05$) (figure 3).

Insert Figure 3 about here

Exercise did not cause a significant increase in temperature at 45% in the MS group (*Baseline: 36.7 SD 0.4, peak 37.0 SD 0.5 °C, $p = 0.112$*). At the other intensities the MS group significantly increased temperature, returning to baseline 35min into the recovery period at 60% (*Baseline: 36.7 SD 0.4 °C, peak 37.1 SD 0.6 °C, $p > 0.001$*) and at 25min at 90% (*Baseline: 36.6 SD 0.4 °C, peak 36.9 SD 0.5 °C, $p = 0.001$*). In the control group temperature did not significantly increase at 45% (*Baseline: 36.7 SD 0.3 °C, peak 36.8 SD 0.2 °C, $p = 0.645$*) or 60% (*Baseline: 36.7 SD 0.1 °C, peak 36.9 SD 0.6 °C, $p = 0.538$*). At 90% (*Baseline: 36.7 SD 0.2 °C, peak 37.0 SD 0.4 °C, $p = 0.007$*) there was a significant increase in temperature returning to baseline at

8min. Over all there was no significant difference between exercise intensities ($p=0.996$) or group at each intensity (45% $p=0.742$, 60% $p=0.678$, 90% $p=0.489$).

Insert Table 3 about here

Logically, the majority of perceived and physiological measures correlated during recovery for both groups across intensities, (Table 3). However, notably, correlations between temperature and RPE (RPEBre and RPEleg) were only found in the MS group. In addition correlations were found between MEP area and RPEleg and RPEbre for the MS group at both 45% and 60%, after continuous exercise. In the control group correlations were only found between MEP area and RPEleg at 45% and RPEbr at 90%.

The vital questionnaire administered the day following exercise sessions in the MS group showed no difference in vitality the next day (**45%**: pre-exercise 4.9 SD 1.5, next day 5.2 SD 1.7, $p=0.498$, **60%**: pre-exercise 5.3 SD 2.0, next day 5.2 SD 2.1, $p=0.951$, **90%**: pre-exercise 5.3 SD 2.1, next day 5.4 SD 1.7, $p=0.338$) and no participants report any adverse reactions.

Discussion

To our knowledge this is the first study to investigate physiological, neurophysiological and perceptual markers of effort following cycling exercise of differing intensity in pwMS. We found a similar response and recovery to exercise in pwMS and a sedentary, yet more active, control group across low and high intensities. However, there were some notable differences that may be important for exercise prescription. PwMS group took longer to recover from feelings of leg fatigue after exercising at intensities used for training **programs, which had**

previously only been observed after maximal exercise [7]. In addition exercise induced increases in tympanic temperature correlated with recovery of perceived fatigue, supporting previous research on the importance of considering temperature during exercise in pwMS [31].

Heart rate response

When interpreting these findings it is important to consider that exercise intensities were relative and therefore more absolute work was performed by the control group. Nevertheless heart rate data indicated that the physiological effort required at the relative intensities was similar between groups and we found no evidence of the altered HR response, which has previously been reported at the commencement of exercise in some pwMS [32]. Whilst, pwMS took longer to recover at 45%, our result also suggest a normal HR recovery, as previously found after maximal exercise [7]. A recent systematic review for exercise training for pwMS found that training programs of 2 to 3 times per week for 30 to 60 minutes at 60%–80% of maximum are required to improve aerobic fitness [4]. We found 60% continuous and 90% intermittent exercise was achievable during the 20 minute exercise period.

Perceptual response

The RPE-CR10 scale is purported to be a robust measure that reflects exercise intensity at least as well as heart rate [33]. Indeed current exercise guidelines for pwMS [34] advice that 5 to 6 on a scale of 10 can be used to determine moderate intensity aerobic activity. The MS group average RPE for Legs and breathing did not reach this level even during the 60% session. However, the exercise sessions only lasted 20mins and the RPE trajectories would indicate higher RPEs after 30mins of exercise. Exercise intensity has been identified as an important determinant of

adherence to exercise prescription [35]. PwMS may be less tolerant to regular participation in higher intensity exercise due to chronic fatigue and a delayed recovery of feelings of leg fatigue following exercise [7]. Our results suggest that the perceptual fatigue may be prolonged following both low and high intensity exercise in pwMS. Essentially, RPE for both legs and breathing recovered slower in the MS group whose feelings of leg fatigue tended to take longer to recover than breathing. Dawes et al[7] postulated that deficits in central drive reducing the ability to perform powerful movements[36] may account for the slower recovery of leg fatigue symptoms found after maximal exercise. Our results support this, as the time taken for feelings of leg fatigue to recover increased with intensity, not total amount of work done. **The 90% session was the same amount of total work as the 45% session, and a third less than the total work performed during 60% session. However, RPElegs took more than twice as long to recover after 90% intermittent cycling (35mins) than after 60% continuous cycling (15mins) and more than 5 times longer than 45% continuous cycling (6mins).** Conversely, recovery of RPEbre was consistent between intensities taking between 6-8mins to recover in the MS group.

Neurophysiological response

We used TMS to investigate the neurophysiological response to exercise. A review of neurophysiological response to muscular fatigue in MS [37] found lack of consensus in the literature with studies showing; no-post exercise MEP depression, depression the same as in controls and depression greater in MS than that in controls. We found MEPs were significantly depressed in the MS group at 45% and 60% and at all intensity in the control group but no differences between groups. To our knowledge this is the first study that TMS has been used to compare changes in

corticospinal excitability after exercise sessions that are analogous to those which may form an exercise program as most previous studies have used repeated contractions to induce local muscle fatigue in the upper limb [22,38]. The MEP data suggests that in the MS groups reduced corticospinal excitability may be more related to total work performed rather than intensity, as MEP depression was greatest after the 60% exercise session, total work a third greater than 45% and 90% (mean MEP area 52%), but similar after 45% and 90% exercise sessions (mean MEP area ~80%), when total work performed during the exercise was the same. Interestingly, we found corticospinal excitability related to recovery of exertional symptoms, following continuous exercise but not intermittent exercise in pwMS.

Temperature response

MEP size may be affected by multiple factors, such as temporal dispersion of the descending volley, partial or complete conduction block, frequency dependent conduction block or impedance mismatch [38]. In pwMS conduction may also be affected by temperature. Humm et al [39] found Uhthoff phenomenon (increases in body temperature that lead to an intensification of MS symptoms) occurs in pwMS with central conduction slowing and these individuals were particularly vulnerable to develop temperature-dependent central motor conduction block. Flensner et al [40] found heat sensitivity (propensity to Uhthoffs phenomena), present in 58% of pwMS and that it was a significant factor relating to fatigue. We found significant increases in tympanic temperature that correlated to exertional symptoms during recovery in the MS group but not the control group. These results suggest that the temperature of the exercise environment and/or possible adoption of cooling strategies should be considered. Indeed preliminary studies have found cooling strategies have decreased the sense of fatigue [41] and increased exercise durations [31].

Limitations

This study has a number of limitations to consider, The relatively small number of participants, number of measurements, and heterogeneous nature of MS mean both between groups and exercise intensity differences would only reached standard levels of statistical significance when large effect sizes existed. **Due to the novel and exploratory nature of the study a pragmatic approach was used determine sample size and no formal sample size calculation was under taken. However, post hoc analysis found moderate effect sizes (~0.55 – 0.65) at measurement points where differences between exercise intensities were greatest in the MS group, with an optimised design a sample size of 30 may have statistically confirmed these differences. The results of the study may help direct future studies to identify specific questions and employ more efficient designs.** **Indeed** the sample size also made it inappropriate to further stratify the MS group by severity of fatigue and heat sensitivity, **and we did not determine if any of our participants with MS had autonomic dysfunction, which could have affected heart and temperature responses;** these **aspects** should be considered in future studies with similar aims. The characteristics of our MS sample should be considered when generalising our findings and it should be noted **approximately half the group had progressive MS. In addition** whilst, our control group were similar in terms of gender, age, height, and weight, **they were not matched** and were more active (although sedentary) and fitter. Lastly, whilst not the gold standard, the tympanic temperature measurement used in this study has been shown to provide a reliable, accurate measure of body temperature measurement when

compared to bladder and rectal thermometry [42, 43]. However, the accuracy of tympanic thermometers can be affected by incorrect technique [44]. Researchers in the present study were highly practised having recorded several thousand measures during almost 300 sessions. Each measure was checked for consistency, and in the event of an anomaly or suspect reading, temperature was immediately re-taken.

Exercise prescription

Systematic reviews to inform exercise recommendations have focused on the effectiveness of exercise in improving outcomes with the aim of identifying minimum [4, 34] or optimum exercise dose [45]. However, the most recent guidance is on based evidence from studies with a mean duration of 10.25 (SD 5.98) weeks [4]. Thus, a limitation of the current recommendations is the lack of evidence for longer-term interventions to determine if exercise is maintained. Certainly, given the progressive nature of the disease studies with long follow-up periods are required to investigate if exercise benefits are sustained over the longer-term. Furthermore the reporting of adherence and dropout is generally poor in MS exercise trials. Pilutti et al [46] found only 65% of the studies included in a review of the safety of exercise training in MS included a CONSORT flow diagram [47]. **Whilst, we had no adverse reactions and the exercise sessions did not affect feelings of vitality the following day, being too tired is the main barrier pwMS give to exercise [48]. We found leg fatigue took longest to recover after high intensity exercise, which may effect longer term participation in this type of exercise.** Indeed, Collett et al [6] found high intensity intermittent exercise less well tolerated in terms of attendance at sessions and people discontinuing the intervention than continuous

training. **This concept is** currently being considered in a trial [8] (NCT01611987) in which the intervention includes 'PUSH' day of high intensity exercise chosen by the individual to **empower them to balance rest and activity by selecting days to work at high exercise intensity. Certainly fundamental to effective participation is the individual's attitude toward the prescribed exercise.**

Conclusion

This study showed that, in pwMS, the time taken to recover from feelings of leg fatigue increased with the intensity of the exercise session rather than total work performed and was related to increases in body temperature. These findings indicate that when high intensity exercise is undertaken time to recover should be considered. In addition, consistent with previous research, efforts should be made to minimise increases in temperature in order so as not to exacerbate feelings of fatigue.

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Declaration of interest

The authors report no conflicts of interest

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Figure 1. Heart Rate Response during and following exercise at 45%, 60% and 90% of W_{peak}. Shaded area represent exercise period. Solid lines indicate MS group and Dashed lines control group. Arrows indicate the point at which values returned statistically to baseline.

Figure 2. Rating of Perceived exertion during and following exercise at 45%, 60% and 90% of W_{peak}. Shaded area represent exercise period. Solid lines indicate MS group and Dashed lines control group. RPE breathing is indicated by square markers and RPE legs by triangle markers. Arrows indicate the point at which values returned statistically to baseline.

Figure 3. MEP area (% of pre exercise MEP) following exercise at 45%, 60% and 90% of Wpeak. Solid lines indicate MS group and Dashed lines control group. Arrows indicate the point at which values returned statistically to baseline.

