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Exercise induced hypoalgesia is elicited by isometric, but not aerobic exercise in individuals with chronic whiplash associated disorders

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HIGHLIGHTS

- An isometric wall squat exercise reduced pain sensitivity in individuals with chronic WAD.
- Thirty minutes of cycling did not increase pain sensitivity.
- Descending pain modulation was not associated with exercise induced hypoalgesia.
- Psychological factors were not associated with pain sensitivity following exercise.

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ABSTRACT

Background and aims: Reduced pain sensitivity following exercise is termed exercise induced hypoalgesia (EIH). Preliminary evidence suggests that impairment of EIH is evident in individuals with whiplash associated disorders (WAD) following submaximal aerobic exercise. This study aimed to compare EIH responses to isometric and aerobic exercise in patients with chronic WAD and healthy controls and investigate relationships between EIH, conditioned pain modulation (CPM) and psychological factors in patients with chronic WAD.
Methods: A cross sectional pre-post study investigated the effect of a single session of submaximal aerobic cycling exercise and a single session of isometric timed wall squat exercise on EIH in a group of participants with chronic WAD ($n = 21$) and a group of asymptomatic control participants ($n = 19$). Bivariate analyses between EIH and baseline measures of CPM and psychological features (fear of movement, pain catastrophization and posttraumatic stress symptoms) were also investigated.
Results: The isometric wall squat exercise but not the aerobic cycling exercise resulted in EIH in both groups ($P < .023$) with no between-group differences ($P > .55$) demonstrated for either exercise. There were no significant associations measured between EIH (for either exercise performed), and CPM, or any of the psychological variables.
Conclusions: This study showed that individuals with chronic WAD and mild to moderate pain and disability, and no evidence of dysfunctional CPM, demonstrated reduced pain sensitivity, both in the cervical spine and over the tibialis anterior following an isometric, timed wall squat exercise. Cycling exercise did not increase pain sensitivity.
Implications: Individuals with chronic WAD and mild to moderate levels of neck pain and disability may experience less pain sensitivity both locally and remotely following an exercise program directed at non-painful muscles performing isometric exercises. Individuals cycling for 30 min at 75% of age-predicted heart rate maximum do not experience increased pain sensitivity.

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1. Introduction

Reduced pain sensitivity following exercise is termed exercise induced hypoalgesia (EIH) [1,2] and is believed to result from activation of endogenous pain inhibitory processes [3]. In contrast to responses in healthy, pain-free individuals [4,5], various painful conditions, such as fibromyalgia, demonstrate dysfunction of endogenous pain inhibitory processes that results in increased sensitivity to pain (reduced thresholds) following aerobic and isometric exercise [5,6].

In chronic whiplash associated disorders (WAD), dysfunction in endogenous pain control have been demonstrated [7,8]. Furthermore, preliminary evidence suggests that EIH is also impaired with submaximal (<75% of age-predicted maximal heart rate) or physiologically limited (<80% of heart rate corresponding to anaerobic threshold) cycling exercise resulting in hyper not hypoalgesia [9]. The reasons for impaired EIH in chronic WAD are unknown, but are likely multifactorial. Individuals with chronic WAD primarily present with regional neck pain, but their clinical presentation may also include pro-nociceptive features (e.g. sensory hypersensitivity presenting as reduced pressure and thermal pain thresholds) and various psychological features including pain catastrophization, posttraumatic stress symptoms and fear of movement/re-injury [10]. Psychological features have been demonstrated to influence endogenous analgesia, with recent research demonstrating that greater pain catastrophization predicts diminished EIH (as measured by temporal summation) in healthy pain-free individuals [11]. However, research in patient groups is lacking. The type of exercise performed may be another factor that influences EIH [12]. Isometric exercise of non-painful muscles reduces pain sensitivity in people with shoulder pain, but not in individuals with widespread pain conditions, such as in fibromyalgia [13]. The relationship of pro-nociceptive features, exercise type and psychological features to EIH has so far not been investigated in chronic WAD.

Endogenous analgesia in chronic WAD has previously been evaluated utilizing the Conditioned Pain Modulation Paradigm (CPM) [7,8], whereby reduced endogenous pain inhibition has been demonstrated. It has been shown that EIH and CPM responses after exercise in healthy individuals are similar [14]. In addition, CPM has been demonstrated to predict EIH in healthy individuals [15]; but this relationship has so far not been investigated in a patient group. Further investigation of the relationship between CPM and EIH is warranted to determine if there are similar mechanisms underlying endogenous analgesia.

The aims of this study were:

1. To compare EIH responses to isometric and aerobic exercise in patients with chronic WAD and healthy controls
2. To determine if there is a differential response of exercise type on EIH
3. To investigate relationships between EIH and CPM in patients with chronic WAD
4. To investigate relationships between EIH and psychological factors in patients with chronic WAD.

It was hypothesized that healthy controls would demonstrate EIH following both types of exercise, and EIH would not occur in chronic WAD. It was also anticipated that a lower CPM response and higher scores on the psychological measures would be associated with impaired EIH.

2. Methods

A cross sectional pre-post study investigated the effect of a single session of aerobic exercise and a single session of isometric exercise on EIH in a group of participants with chronic WAD and a group of asymptomatic control participants.

2.1. Participants

Individuals with WAD were eligible to participate if they presented with Whiplash Grade II (neck pain but no fracture/dislocation of the neck and no neurological deficit [16]) of at least 3 months but less than 10 years duration and were aged between 18 and 65 years. Individuals were excluded if they had known or suspected serious spinal pathology (e.g. metastatic, inflammatory or infective diseases of the spine); confirmed fracture or dislocation at the time of injury; nerve root compromise (at least 2 of the following signs: weakness/reflex changes/sensory loss associated with the same spinal nerve); spinal surgery in the previous 12 months; history or presentation of psychosis, bipolar disorder, organic brain disorder or severe depression; were taking anti-depressant or anti-convulsant medication; or who answered 'yes' to *any* of the 7 questions on the PAR-Q physical activity screening questionnaire [17].

Healthy control participants were eligible to participate if they did not have a history of WAD or recent (within the previous 12 months) musculoskeletal pain and did not answer 'yes' to any questions on the PAR-Q.

2.2. Procedure

Volunteers who met the inclusion criteria were invited to attend two testing sessions: one to perform submaximal aerobic bicycle exercise; and a second to complete an isometric exercise. These sessions were scheduled 5–10 days apart. Participants were asked to refrain from analgesics for 48 h prior to testing and to refrain from exercise, nicotine, alcohol and caffeine for 12 h prior to testing. Participant information was provided at the initial testing session, and participants provided informed consent before completing the baseline questionnaire and resting physical measures (Fig. 1). Participants waited 10 min prior to commencing exercise to avoid the testing protocols influencing exercise [18,19]. During this time, resting heart rate and blood pressure measures were collected and appropriate warnings and precautions were provided. Participants then completed an aerobic or isometric exercise session, immediately followed by post-exercise testing. The order of testing was kept constant within each testing session, both prior to and following exercise (Fig. 1). Ethical clearance for this study was granted by the institutional Medical Research Ethics Committee.

2.3. Exercise sessions

2.3.1. Aerobic exercise

Participants completed a standardised, submaximal bicycle ergometer test [20]. Prior to starting the test, the rating of perceived exertion (RPE) scale was explained to participants [21] and 75% of age-predicted maximum heart rate was calculated (.75 × (220-age in years)). The participant started to cycle at 25 W and the power output was increased by 25 W every minute until attainment of 75% of age-predicted maximum heart rate. The participant continued to cycle at this power output for a total duration of 30 min [20]. The Aerobic Power Index test has been shown to be reliable for healthy populations and populations with chronic medical conditions, and enables completion of a standardised, 30 min aerobic exercise session [22]. Heart rate, RPE and blood pressure were recorded each minute during the increase in power output and then once every 3 min until the end of the exercise session.