



# International Journal of Sports Science & Medicine

## Research Article

# Responses to Modified Aerobic Exercise Prescription for Chronic Pain Participants Compared to Healthy Controls -

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**Submitted:** 15 September 2017; **Approved:** 20 October 2017; **Published:** 23 October 2017

**Cite this article:** Micalos PS, Jesulola E, Pak S, Drinkwater EJ, Cannon J, et al. Responses to Modified Aerobic Exercise Prescription for Chronic Pain Participants Compared to Healthy Controls. *Int J Sports Sci Med.* 2017;1(2): 048-054.

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## ABSTRACT

The aim of this research was to evaluate the effects of modified Aerobic Exercise Prescription (AEP) on health-related outcomes in participants with chronic pain compared to healthy controls. Participants included eleven chronic pain (mean age  $50 \pm 12$  years) and 8 healthy controls ( $49 \pm 10$  years). AEP was performed 2 days per week over a 12-week period. For both groups the exercise prescription involved performing aerobic exercise at 60 - 80% of predicted maximum heart rate, however, the perception of muscle pain during exercise was modified to below somewhat-strong pain levels by lowering the exercise intensity. The measured outcomes included health status (SF36), percent body fat, 6 min walk test (6MWT), cardiovascular fitness (HR/Watt), exercise power output (Watts), and pain evaluation (MPQ-Total). Measured outcomes are conveyed as percentage change (%) and effect size (Cohen's  $d$ ) with 95% Confidence Limits (CL). Results show that the chronic pain participants presented 40.8% lower exercise power output ( $-36.2$  W, 95% CL:  $-54.8$  to  $-17.7$ ) due to elevated muscle pain levels during exercise compared to healthy controls. Following modified AEP the chronic pain group improved 29% in SF36-Total health ( $d = 0.57$ ; 95% CL:  $-0.45 - 1.6$ ), 5.1% increase in the 6MWT ( $d = 0.36$ ; CL:  $-0.34 - 1.07$ ), 16.7% increase in Watts ( $d = 0.43$ ; 95% CL:  $-0.02 - 0.88$ ), and 26% reduced chronic pain (MPQ - Total), ( $d = -0.41$ ; 95% CL:  $-1.15 - 0.33$ ). Comparison of the Pre and Post cardiovascular fitness (HR/Watt) for the healthy control group revealed a small -12.2% reduced HR/Watt ( $d = -0.2$  bpm, 95% CL:  $-0.3$  to  $-0.1$ ), and a large 43.5% enhanced exercise power output ( $d = 44.5$  W, 95% CL:  $13.5$  to  $75.6$ ). AEP is associated with clinically relevant changes in reducing pain, increased health status and improving exercise tolerance in participants with chronic pain.

**Keywords:** Exertional pain; McGill Pain Questionnaire; SF36 Health status; Exercise tolerance

## INTRODUCTION

Chronic pain refers to pain that persists beyond the expected healing time [1,2] and sustains a significant impact on health and functional status [3]. Participants with chronic pain often present with diminished health status, decreased physical fitness, and reduced functional capacity [4]. Deconditioning is a significant problem in chronic pain sufferers since debilitating pain inhibits activity and cultivates a fear of movement. Exercise therapy potentially improves exertional tolerance and enhances health status in chronic pain sufferers [5]. Previous research shows that chronic pain participants prefer an individually mediated exercise intensity compared to a prearranged exercise intensity [6]. However, the optimal exercise prescription for preventing excessive exertional pain and enhancing exercise capacity in chronic pain sufferers has not been fully detailed. Previous research on aerobic exercise therapy has demonstrated reduced pain [7,8] enhanced health status [9] and improved physical function [10] in participants with chronic pain. In contrast, others have reported no decline in pain [11] or exacerbation of pain [12] and no improvement in physical function [13] in chronic pain participants following exercise therapy. Exercise prescription based on cardiovascular parameters such as heart rate response during exercise is problematic in chronic pain participants because of reduced exercise tolerance [14]. Instead, psychophysical tools such as perceptual rating scales can be applied in exercise therapy to dynamically mediate the exercise intensity and avert excess pain during exercise for chronic pain participants [6]. Further research is required to examine the efficacy for this type of individualized aerobic exercise therapy in persons with chronic pain [4]. Maintaining exercise program adherence is a significant quandary in participants with chronic pain [15,16]. Adherence to exercise therapy is often compromised in chronic pain participants due to the exacerbation of pain and fatigue [12] compared to healthy control participants. In contrast, self-paced aerobic exercise has been associated with enhanced program adherence and symptom improvement in chronic pain participants [17]. On this basis, customised exercise prescription that mediates exertional pain during exercise in chronic pain participants may show enhanced program adherence and therapeutic effects. Therefore the purpose of this study was to evaluate the effects of modified aerobic exercise prescription in participants with chronic pain by using perceptual rating scales and compare this with healthy control participants.

## METHODS

### Ethics statement

The research study was conducted with the approval of the University Ethics in Human Research Committee (approval number 08/07) and all participants signed a letter of informed consent.

### Participants

The participants included 11 diagnosed with chronic pain (9 women and 2 men) and 8 healthy controls (7 women and 1 man). Participants with chronic pain included 8 fibromyalgia, 2 chronic back pain, and 1 individual with complex regional pain. Inclusion criteria for the chronic pain group were chronic pain diagnosis by a general medical practitioner, rheumatologist or pain specialist for at least 12 months prior to participation in the present study. Previous treatments among the chronic pain group included spinal surgery in 2 participants and limb trauma surgery in 1 participant. The inclusion criteria for the healthy control participants were required to be absent of acute or chronic illness or disease. For both groups the age range criterion of between 25 - 65 years was required.

The exclusion criteria for all participants were persons with acute inflammatory conditions and musculoskeletal disorders. Three participants were excluded from the study due to scheduled eye surgery, pregnancy, and due to locomotor problems. Mean age and physical characteristics of the chronic pain and healthy control groups are shown in Table 1. All chronic pain participants reported regularly using over-the-counter anti-inflammatory and analgesic medications, four reported using prescription opioid-based medicines, and three chronic pain participants were using prescription anti-depressants. The chronic pain participants were requested to maintain their standard medication protocol for the duration of the study.

### Experimental design

The design of the study was a within-group and between-group comparison. Within-group measures were performed before (Pre) and after (Post) 12 weeks of aerobic exercise therapy. Between-group measures were performed between the chronic pain and healthy control group at Pre and at Post AEP. Comparisons were performed between chronic pain and healthy control groups in order to contrast the exercise capacity and health status between these groups. The measured outcomes included exercise program



attendance, health status, anthropometric characteristics, functional capacity, cardiovascular fitness, and psychobiological responses during exercise for the chronic pain and healthy control participants.

### Anthropometric and health status assessment

Anthropometric assessment of body mass and body fat percentage at Pre and Post AEP were performed by whole-body dual-energy x-ray absorptiometry (DXA; Norland XR - 800, Fort Atkinson, WI, USA). Baseline measures of body mass and body fat percentage assessed at Pre AEP are shown in Table 1. The health status for chronic pain participants and healthy control participants was assessed by SF36 questionnaire [18] at Pre and Post aerobic exercise therapy.

### Functional capacity and cardiovascular fitness assessment

Each participant completed a 6 Min Walk Test (6MWT) at Pre and Post AEP as a measure of functional capacity [19]. Participants were encouraged to perform their peak walking speed for 6 min on a flat surface area. Baseline measurements of the 6MWT performed at Pre AEP for the chronic pain and healthy control groups are shown in Table 1. Each participant also completed a sub-maximal cycling exercise test (HR/Watt) at Pre and Post AEP to assess the change in cardiovascular fitness. Exercise HR and power output (W) were recorded at each minute over a 4 min steady state during a workload that elicited a Rating of Perceived Exertion (RPE) of 12 (scale 7 - 20) and perception of Muscle Pain Intensity (MPI) of less than 4 (scale 0 - 10). The sub-maximal exercise power output (W) performed at Pre was repeated at Post AEP and the heart rate was averaged at this workload for comparison with Pre AEP.

### Aerobic exercise prescription and program adherence

All chronic pain and control participants were individually supervised during each exercise session for the duration of the study. Participants performed aerobic exercise by treadmill walking or recumbent cycling for 20 min, 2d-wk<sup>-1</sup>, for 12-weeks. For both groups the exercise prescription involved performing aerobic exercise at 60 - 80% of predicted maximum heart rate, however, the exercise workload was adjusted according to perceptual responses to exertion and pain levels during exercise. Both the RPE and MPI were assessed at 1 min intervals during exercise. The measurement of the RPE during exercise was derived from the psychophysical concept developed by Borg [20]. The RPE was maintained within identifiable chart anchors between 11 and 13 on the Borg 6 - 20 category ratio scale. The MPI during exercise was mediated to below somewhat-strong pain levels by lowering the exercise intensity. Muscle pain intensity during exercise was perceptually assessed by participants at 1 min intervals and was maintained below a rating of '4 - Somewhat Strong Pain', using 0 - 10

category ratio scale [21]. If the muscle pain intensity increased above 4, then the exercise intensity was reduced. The exercise duration was increased from 10 to 20 min gradually during the initial 4 sessions. During exercise, 3 intervals of enhanced workload for 1 min at 20% above steady state exercise were performed to stimulate training adaptation. Exercise power output (Watts) and Heart Rate (HR) were recorded each minute from the exercise equipment display and by HR telemetry (HR monitor, Polar RS200, Polar Electro, Kempele, Finland), respectively. The attendance rate was determined by the percentage of completed exercise sessions within the duration of the therapy period. The attrition rate was determined by the number of participants that did not complete the Post assessments.

### Pain assessment

Pain appraisal by questionnaire was completed by chronic pain participants at weekly intervals for the duration of the AEP. Appraisal of pain was assessed by the McGill Pain Questionnaire (MPQ) [22]. The MPQ is a validated and reliable instrument for measuring subjective qualities of pain in humans. This instrument provides a total pain rating index (MPQ - Total) and three major classes showing distinctive components of pain experience including the MPQ - Sensory, MPQ - Evaluative, MPQ - Affective [23].

### Statistical analysis

Due to the present study being underpowered we performed comparisons between chronic pain and control groups at Pre and Post aerobic exercise therapy by determining the effect size and confidence limits [24]. A standardized Cohen's effect size (*d*) was determined for the mean change and for lower 95% and upper 95% Confidence Limits (CL), [25]. Standardized Cohen's effect size offers details on changes in measured outcomes that are clinically meaningful and relevant [24]. Thresholds for qualitative descriptors for effect sizes are  $\pm 0.2$  = small effect, 0.5 = medium effect,  $\pm 0.8$  = large effect. The application of standardised Cohen's effect size and confidence limits has previously been performed in chronic pain and exercise therapy research [26] to reveal clinically meaningful changes. Cohen's *d* is presented in figures as solid dot (•) together with 95% confidence interval, presented as horizontal bar. The threshold for smallest effect size ( $\pm 0.2$ ) is shown as a vertical broken line. A 95% confidence interval that does not graphically intersect the central median (solid vertical line) has a  $P < 0.05$ . A reduction of approximately 30% or 2 points in the 11-point pain intensity numerical rating scale have been shown to represent an important difference in chronic pain clinical trials [15]. Average MPQ scores were determined between 0-2 weeks (Start) and the final 2 weeks (End) of aerobic exercise therapy. Comparison for program attendance between chronic pain and control participants were performed using *t*-test.

## RESULTS

### Participant characteristics

The mean duration of chronic pain in the pain group was 7.3  $\pm$  4.9 years. None of the chronic pain participants reported additional concurrent treatments or changes in medication during the study.

### Exercise responses and program attendance in the chronic pain and control participants

The mean exercise RPE and MPI in the first two weeks for the chronic pain group was 11.4  $\pm$  1.2 and 2.7  $\pm$  1.2 ratings points, respectively. The chronic pain group reported muscle pain during exercise; however, the exercise intensity was reduced to lower the

**Table 1:** Anthropometric and functional characteristics of the chronic pain and healthy control participants. Data are expressed as mean  $\pm$  SD.

	Chronic pain patients (n = 11)	Healthy controls (n = 9)
Age (years)	50 $\pm$ 12	49.6 $\pm$ 10
Body mass (kg)	98.7 $\pm$ 20	79.1 $\pm$ 5.0
Body fat %	47.9 $\pm$ 7.8	39.9 $\pm$ 8.0
6MWT (m)	428.1 $\pm$ 59.8	650.1 $\pm$ 90.9
Exercise power output (Watts)	50 $\pm$ 19	102.4 $\pm$ 41



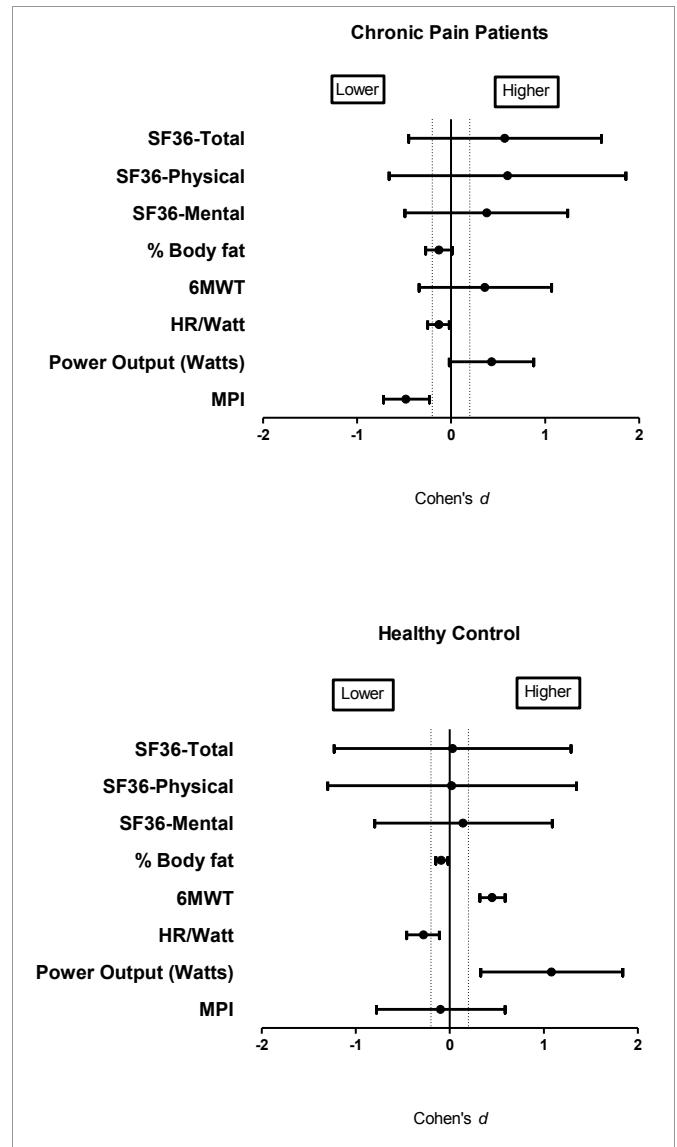
muscle pain intensity level to below ‘somewhat strong pain’. Mean RPE and MPI (mean ± SD) for the healthy control group was 11.6 ± 0.6 and 0.5 ± 0.6 ratings points, respectively. The mean exercise HR as a percentage of predicted maximum HR for the chronic pain group was 65.3% ± 9.1 and for the healthy control group was 71.3% ± 10.9. All participants completed the Pre and Post AEP assessments. The mean AEP program attendance for the chronic pain group was 73.9% ± 23.7 and for the healthy control group was 92.7% ± 4.0 (*P* = 0.03).

**Between-group comparisons for health status and cardiovascular fitness (chronic pain vs control)**

Differences in the measured outcomes between the chronic pain participants and healthy control group at Pre aerobic exercise therapy are shown in Figure 1. Comparisons for the SF36 health scores revealed a large 61.4% difference for SF36-Total ( - 47 points, 95% CL: - 60.8 to - 33.3; mean chronic pain 29.6 ± 15.3, mean Control 76.7 ± 12). Additional measures of health components show - 70.6% lower SF36 - Physical ( - 52.9 points, 95%CL: - 64.5 to - 41.2), and - 52.2% lower SF36 - Mental ( - 38.9 points, CL: - 56.6 to - 21.3) at Pre aerobic exercise therapy. Assessment for body characteristics at Pre revealed a large 20% higher body fat percent for the chronic pain group compared to the healthy group (8%, 95% CL: 0.3 to 15.7). The functional capacity and cardiovascular fitness in the chronic pain group compared to the healthy control group at Pre revealed a large difference of -34.2% in the 6MWT ( - 222.1 m, 95% CL: - 294.8 to - 149.4), - 40.8% reduced exercise power output ( - 36.2 W, 95% CL: - 54.8 to - 17.7), and 63.7% elevated HR/Watt (1 bpm, 95% CL: - 0.1 to 2.0).

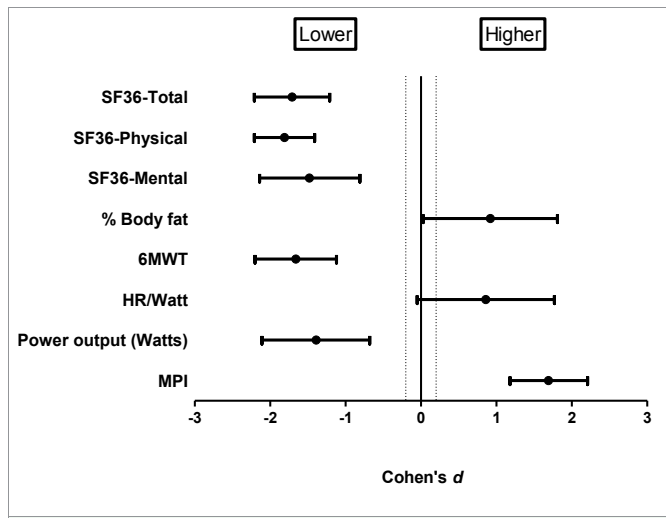
**Within-group comparisons (chronic pain and control group) for health status and cardiovascular fitness following aerobic exercise therapy (Pre vs Post)**

The effect size and confidence limits between Pre and Post measured outcomes for the chronic pain and healthy control groups are shown in Figure 2. The health status in the chronic pain group revealed a moderate 29% improvement in the SF36 - Total health (8.7 points, 95% CL: - 6.9 to 24.4), moderate 29.3% enhanced SF36 - Physical health (6.5 points, 95% CL: - 7.2 to 20.1), and a small 21.4%



**Figure 2:** Changes (• Cohen's d, 95% CL) between Pre and Post aerobic exercise therapy in the chronic pain and the healthy control groups for Health Status (SF36), Body composition (% Body fat), 6MWT, exercise power output (Watts), Cardiovascular fitness (HR/Watt), and Muscle Pain Intensity During Exercise (MPI).

improved SF36-Mental health component (7.6 points, 95% CL: - 9.9 to 25.2) between Pre and Post AEP. Assessment for body composition did not show a meaningful reduction in the percentage body fat between Pre and Post AEP for the chronic pain group (Cohen's *d* between - 0.2 and 0.2). Evaluation of the functional capacity for the chronic pain group revealed a small 5.1% improvement for the 6 min walk test (21.8 m, 95% CL: - 20.4 to 64). The effect size change in cardiovascular fitness (HR/Watt) for the chronic pain group is considered trivial (-0.2 HR/W, CL: - 0.3 to - 0.03), however, there was a strong trend towards a reduced HR response to the exercise intensity. Comparisons of exercise power output show a small 16.7% increase in Watts (8.4 W, 95% CL: - 0.3 to 17) and a moderate 20.4% reduction of the muscle pain intensity during exercise ( - 0.5 points, 95% CL: - 0.8 to - 0.3) in the chronic pain group. Clinically meaningful changes in SF36 Total health status (mean Pre 76.7 ± 12.0, mean Post 77.0 ± 13.2) and the percent body fat (mean Pre 39.9 ± 8.0, mean Post 39.2 ± 8.2) were not observed in the healthy control



**Figure 1:** Differences (• Cohen's d, 95% CL) between the chronic pain and healthy control group at Pre aerobic exercise therapy for Health Status (SF36), Body composition (% Body fat), 6 Min Walk Test (6MWT), Exercise power output (Watts), Cardiovascular fitness (HR/ Watt), and Muscle Pain Intensity during exercise (MPI).



group following the AEP, however, there were a significant trend for reduced percent body fat. Assessment of the 6MWT between Pre and Post for the healthy control group revealed a small 6.3% enhanced 6 min walk test (41 m, 95% CL: 28.7 to 53.4). Comparison of the Pre and Post cardiovascular fitness (HR/Watt) for the healthy control group revealed a small -12.2% reduced HR/Watt (-0.2 bpm, 95% CL: -0.3 to -0.1), and a large 43.5% enhanced exercise power output (44.5 W, 95% CL: 13.5 to 75.6). The muscle pain intensity during exercise revealed a trivial 10.4% reduction following the AEP (-0.05 points, CL: -0.4 to 0.3).

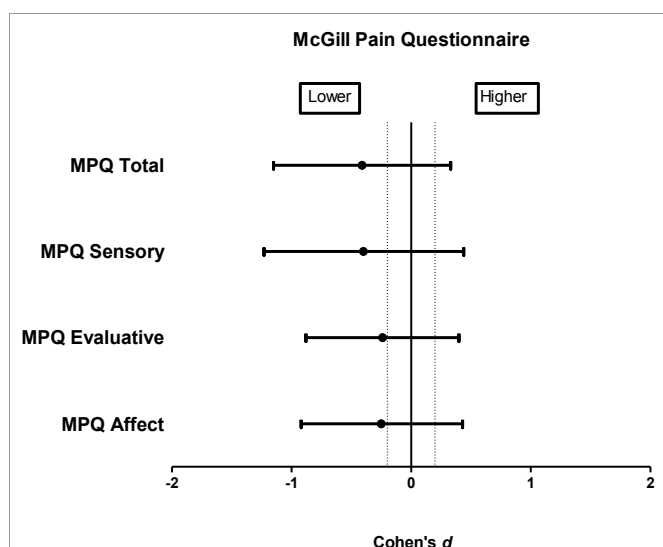
### Pain assessment in the chronic pain group

Comparisons for the McGill Pain Questionnaire (MPQ) between Start and End of the AEP within the chronic pain group are shown in Figure 3. Results for the MPQ-Total reveal a small -26% reduction between Start-End (-5.0 points, 95% CL: -13.8 to 0.6) in the chronic pain participants. There was a small -27% reduced MPQ-Affective pain scale between Start-End (-0.6 points, 95% CL: -1.9 to 0.4). There was a small -22.3% reduction (-2.7 points, 95% CL: -8.2 to 2.9) in the MPQ-Sensory pain scale between Start-End. There was a small -15% reduction (-0.3 points, 95% CL: -1.0 to 0.5) in the MPQ-Evaluative pain score between Start-End.

## DISCUSSION

The present findings show that chronic pain participants reveal substantially elevated muscle pain and Reduced Exercise Power output at equivalent perceived exertion levels (RPE) compared to healthy control participants. This is in accord with previous findings showing that chronic pain participants perceive exercise as painful [27]. However, the muscle pain intensity during modified exercise prescription in the present study was mediated to avert strong pain levels by reducing the exercise intensity. This prescription of modified aerobic exercise performed over 12 weeks revealed a decrease in exertional pain and a substantial improvement in exercise power output for the chronic pain participants. Despite the mediated exercise intensity, the chronic pain group were able to perform mild-moderate cardiovascular exercise at 65.3% of maximum heart

rate. These results suggest that the application of psychophysical tools such as RPE and muscle pain intensity during aerobic exercise shows increased exercise tolerance in participants with chronic pain. Exercise prescription for participants with chronic pain is often associated with a reduced adherence to the therapy program [12]. Previous research shows high drop-out rates in chronic pain participants during exercise therapy with a median of 67% [4,16]. In comparison, all chronic pain participants in the present study completed the AEP program; however, the level of attendance was lower in the chronic pain group compared to the control group. Our attendance rate for the chronic pain group was similar to previous research in chronic pain participants [28]. The basis for the reduced attendance in the chronic pain group was not fully explicated in the present study, however, anecdotal reports include a generalised fatigue not directly associated with the aerobic exercise therapy. Previous research shows that chronic pain participants prefer self-paced aerobic exercise intensity compared to fixed cardiovascular exercise intensity [5]. However, the reduced exercise intensity associated with modified aerobic exercise may limit the development of cardiovascular fitness and improvement in health outcomes. The present results did not reveal a substantial increase in cardiovascular fitness, however, there was a significant enhancement in exercise tolerance and a strong trend towards increased cardiovascular fitness (reduced HR/Watt). Additionally, there was a concomitant reduction in muscle pain rating during exercise in the chronic pain participants. These results indicate that 12-weeks of modified AEP reveal an increase in exercise power output and a reduction in muscle pain in the chronic pain participants. The enhanced exercise tolerance and reduced exertional pain would likely enable increased cardiovascular fitness with continued exercise therapy. The present study assessed the functional capacity of chronic pain participants using the 6 min walk test. These results show a small improvement in the chronic pain group following the AEP. This is in accord with previous studies also showing small improvements in the 6MWT for chronic pain participants [26] following aerobic exercise therapy. However, substantial improvements have been demonstrated with combination aerobic and resistance exercise therapy [29]. In a review study, resistance exercise was shown to demonstrate the largest improvement in functional outcome in chronic pain participants [30]. Therefore, it is possible that aerobic exercise therapy may reveal limited improvement in functional capacity compared to combination aerobic and resistance exercise therapy in chronic pain participants. Following the AEP, the present results demonstrate an improvement in total health score for the chronic pain participants, however, the mental health component showed less improvement compared to the physical health component. Previous research has shown no improvement in mental health scores in chronic pain participants following AEP [7,9]. However, substantial improvements in mental health have been shown with resistance exercise training [7] and with multi-mode exercise program intervention [26]. Enhanced health status with multi-mode exercise intervention compared to single-mode aerobic exercise intervention has been associated with a greater capacity to perform functional daily activities in chronic pain participants [26]. Therefore, it is possible that the reduced improvement in the mental health component following AEP in the present study may be associated with the lower level of improvement in functional capacity within the chronic pain group. Previous research shows an association between increased body weight status and enhanced pain sensitivity in chronic pain participants [31]. Assessment for body characteristics prior to the AEP in the present



**Figure 3:** Changes in the McGill Pain Questionnaire score (• Cohen's d, 95% CL) between Start (average of weeks 1 - 2) and End (average of final 2 weeks) of aerobic exercise in the chronic pain group.



study show a higher body fat percentage for the chronic pain group compared to the healthy group, however, the AEP did not reduce the body fat percentage in the chronic pain group. Similarly, previous studies have shown no improvement in body composition following AEP in chronic pain participants [13]. The present AEP did not reach sufficient exercise dose for weight control [32] within the 12-week period, however, exercise is recognised as a key component towards successful long-term weight management. Results for the pain questionnaire amongst the chronic pain participants show that the total score for pain (MPQ - Total) was attenuated during the AEP. The MPQ-Total revealed a 26% decline in total pain score following the AEP. Previous studies on AEP have shown reductions in pain report that ranged from no improvement [11] to 30% improvement [16]. The reduced total pain score in the present study represents a clinically relevant change [33]. Additionally, the present results also show that the MPQ-Affective score in the chronic pain participants was less responsive to AEP. Long-standing implications and feelings of unpleasantness are associated with the affective pain component [34]. Therefore, it is possible that for substantial reductions in the affective pain component requires continuing multidisciplinary intervention in chronic pain participants. Limitations for the present study is that a small sample of participants was included and therefore results were analysed using effect sizes in order to show a descriptive profile of changes in cardiovascular fitness and health among chronic pain participants. Inspection of individual data suggests that these trends would be observed in a larger sample with significance testing. Additionally, a non-exercise chronic pain group was absent in the present study, however, comparisons were performed with a healthy control group to determine differences in exercise tolerance, adherence and exertional pain in order to determine the optimal exercise prescription for participants with chronic pain.

## CONCLUSIONS

This study shows that modified aerobic exercise prescription is associated with improved program adherence in chronic pain participants. Chronic pain participants showed substantially reduced drop-out rates for the 12 week aerobic exercise prescription compared to previous studies. The modified aerobic exercise prescription also revealed improved exercise power output and reduced muscle pain during exercise in the chronic pain group. Moreover, this aerobic exercise prescription was associated with improved health outcomes and reduced pain in chronic pain participants.

## ACKNOWLEDGMENTS

Funding support for developing the manuscript was provided by the Charles Sturt University 2013 write-up award scheme.

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