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Low volume high intensity interval training leads to improved asthma control in adults

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ABSTRACT

Objective: Regularly engaging in aerobic exercise is associated with improved asthma control and quality of life in adults with mild to moderate severity asthma. Previous intervention research has primarily employed moderate intensity continuous aerobic exercise protocols. As such, the impact of high intensity interval training (HIIT) on asthma control is poorly understood.

Methods: A six-week, low volume HIIT intervention (3 times/week, 20 min bouts) was conducted in adults with asthma ($n=20$). Asthma control was assessed using the Asthma Control Questionnaire-7 (ACQ-7).

Results: ACQ-7 improved from pre to post-intervention (pre: 0.8 ± 0.6 ; post: 0.5 ± 0.4 , $p=0.02$, Cohens $d=0.5$). In total, 7/20 (35%) participants experienced clinically meaningful improvements in ACQ-7.

Conclusion: A low-volume HIIT intervention led to statistically and clinically significant improvements in asthma control as well as improved exertional dyspnea and exercise enjoyment.

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The goal of asthma management is complete asthma control; this includes having no limitations in daily activities (1). Unfortunately, physical activity, particularly of higher intensities, serves as a trigger for acute bronchoconstriction in a large number of adults with asthma (2). Exertional dyspnea, that is, shortness of breath during exercise (3), is commonly experienced among those with asthma, and may be a barrier to regular exercise. Nevertheless, asthma control and exertional dyspnea can be improved by engaging in regular exercise, at least partially due to the improved ability to perform activities of daily living with fewer restrictions (4–6).

Adherence to aerobic exercise among adults with asthma is suboptimal (7). Interestingly, while research suggests that adults with asthma are less likely to engage in higher intensity activities (8), recent work from our laboratory showed that adults with asthma enjoy high intensity interval exercise more than moderate intensity continuous exercise (9). This may be particularly relevant in adults with asthma, as continuous exercise requires a sustained increase in ventilation, which results in evaporative water and heat loss from the airways (10) thus, triggering

bronchoconstriction. In fact, work from our laboratory also found that an acute bout of high intensity interval exercise led to a smaller decline in FEV₁ post-exercise when compared to an acute bout of moderate intensity continuous exercise (9). The high intensity interval exercise was also associated with lower exertional dyspnea during exercise (9).

High intensity interval training (HIIT) is composed of brief bouts of high intensity activity followed by intermittent recovery periods. Based on our work, HIIT appears to be a safe option for exercise prescription; however, limited research exists on the impact of regularly engaging in HIIT on asthma control, exertional dyspnea, and exercise enjoyment. The purpose of this study was to determine the impact of a 6-week, low volume HIIT intervention on asthma control among adults with asthma. We also wanted to determine the impact of HIIT on exertional dyspnea during exercise and exercise enjoyment following the HIIT intervention. We hypothesized that despite the low volume, regular participation in HIIT would lead to improvements in asthma control and exertional dyspnea, because even this low volume intervention would lead to improved cardiorespiratory fitness and

thus a reduction in activity limitations. We also hypothesized that exercise enjoyment would improve due to desensitization to exertional dyspnea symptoms (6,11), and improvements in asthma control.

Methods

Study protocol and participants

A one group pre (first HIIT session), post (last HIIT session) study design was used in which eligible participants (non-smoking, moderately active adults with a self-reported physician diagnosis of asthma, with a current prescription for a short-acting bronchodilator, aged 18–44 years) completed 6 weeks of HIIT, 3 times per week on a cycle ergometer (5 min warm-up at 25 Watts, followed by 10% peak power output for 1 min and 90% peak power output for 1 min, repeated 10 times). Participants completed a ramp incremental maximal exercise test (increase by 1 Watt every 2 s until volitional exhaustion) to determine peak power output at pre and post-intervention. Peak power output was reported as the last workload in which a RPM of 70–80 was maintained. All participants provided written informed consent prior to participation in the study. This study was approved by the Research Ethics Board at the University of Ontario Institute of Technology.

Spirometry

Participants were asked to refrain from taking their short-acting bronchodilator eight hours prior to the pre and post-intervention session. At the first and last HIIT session, participants performed three repeatable lung function maneuvers using a handheld spirometer (EasyOne, Medizintechnik AG, Zurich, Switzerland) before exercise, in accordance with the American Thoracic Society Guidelines (12). Post-exercise measures were taken in duplicate at minutes 5, 10, 15, and 20 post-exercise in accordance with exercise challenge guidelines (13). Although these sessions were not used as an exercise challenge test, and responses were not used for diagnostic purposes, we employed best practices to ensure accurate spirometry data for each time point. The highest FEV₁ value at each of the post-exercise time points was used to determine FEV₁ decline. The decline in FEV₁ was calculated as follows:

$$\% \text{ Fall in FEV}_1 = 100 [(\text{FEV}_1 \text{ pre-challenge} - \text{FEV}_1 \text{ post-challenge}) / \text{FEV}_1 \text{ pre-challenge}].$$

The maximum decline in FEV₁ following exercise was used for statistical analysis. Participants were not

permitted to take their short-acting bronchodilator prior to any of the HIIT sessions; however, they were encouraged to continue use of inhaled glucocorticoids, as prescribed, throughout the duration of the intervention.

Asthma control

Asthma control was assessed using the Asthma Control Questionnaire (ACQ)-7 at pre and post-intervention sessions. The ACQ-7 has been shown to have strong evaluative and discriminative properties and can be used to measure asthma control with confidence (14). It includes an objective measure of lung function (i.e. FEV₁%predicted) as well as an item on limitations in daily activities. A score on the ACQ-7 of <0.75–1.5 is indicative of partially controlled asthma and a score >1.5 indicates poorly controlled asthma. A change on the ACQ >0.5 is considered clinically significant (14).

Exercise enjoyment

Exercise enjoyment was assessed 5-min following completion of the pre and post-intervention sessions using the Physical Activity Enjoyment Scale. Given that the questionnaire was used after completion of the exercise session, it was modified by removing the following question “I am very absorbed in this activity-I am not very absorbed in this activity.” Each question is scored on a 7-point bipolar scale with a maximum score of 119. This modified version has been used previously for the assessment of HIIT (9,15).

Exertional dyspnea

Exertional dyspnea was assessed each minute at pre-intervention (second session) and post-intervention (17th session) using the Ratings of Perceived Dyspnea (RPD) scale. RPD was not measured during the first and last session due to timing of various measurements. The peak RPD and the average RPD for each minute during exercise was used for analysis. The RPD scale has been shown to be valid and reliable for use during exercise (16).

Statistical analysis

Means and standard deviations were used to describe the sample. Paired samples t-tests were used to determine differences between pre and post-intervention sessions. A repeated measures ANOVA was used to determine differences in FEV₁ (L/min) from before and after the exercise session at pre and post-

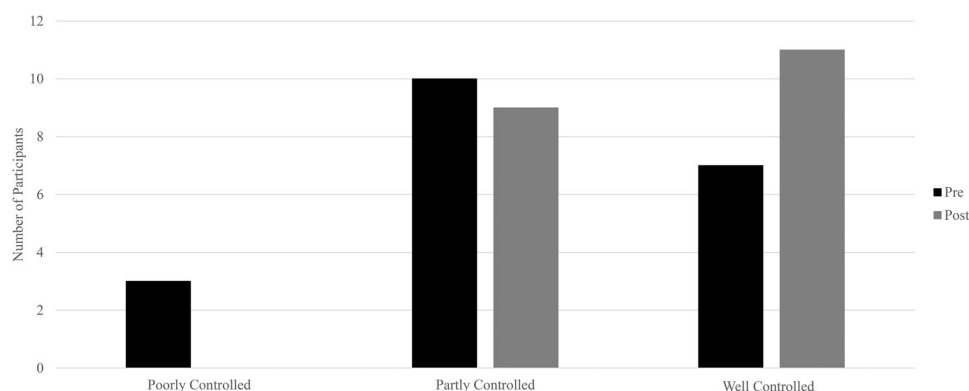


Figure 1. Number of Participants with Poorly, Partly, and Well Controlled Asthma at Pre and Post Intervention.

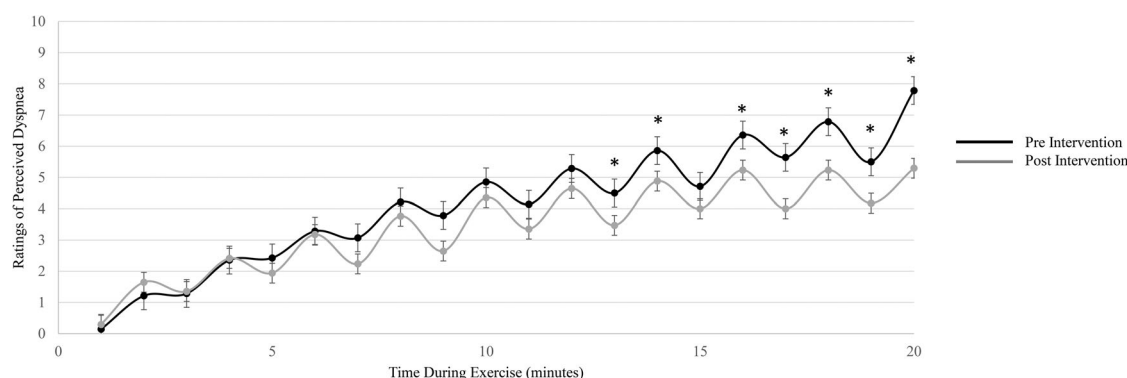


Figure 2. Perceived dyspnea during exercise at pre-intervention and post-intervention ($n = 16$).

intervention sessions. A repeated measures ANOVA was also used to determine differences in RPD during each minute of exercise at pre and post-intervention sessions. Effect sizes were calculated by determining the standardized difference between the two means [(mean pre-intervention)-(mean post-intervention)/standard deviation]. Cohens d effect sizes were categorized as small (0.2), moderate (0.5), or large (0.8). As well, estimated effect sizes were reported using partial eta squared (h_p^2) values from the ANOVA. Partial eta squared effect sizes were categorized as small ($h_p^2 = 0.01$), medium ($h_p^2 = 0.06$), and large ($h_p^2 = 0.14$). All statistics were completed in IBM SPSS statistics 26.0 (Armonk, NY) and statistical significance was declared at $p < 0.05$.

Results

Participants ($n = 20$) were 22.5 ± 3.2 years (11 female). Nine participants had well controlled asthma ($ACQ > 0.5$) and three had poor asthma control ($ACQ > 1.5$) at baseline. The decline in FEV_1 following HIIT at pre and post-intervention sessions (pre: -9.2 ± 8.2 ; post: -4.8 ± 6.8) was the same ($F(1,19) = 0.3$, $p = 0.5$, $h_p^2 = 0.01$).

Improvements in ACQ-7 were observed when comparing pre and post-intervention sessions (pre:

0.8 ± 0.6 ; post: 0.5 ± 0.4 , $p = 0.02$, Cohens $d = 0.5$). A total of 7/20 (35%) participants experienced clinically meaningful improvements in ACQ (i.e. increase of >0.5). Those who experienced a clinically meaningful improvement in asthma control had the highest ACQ-7 at pre-intervention (1.5 ± 0.5 , $n = 7$); no differences were observed between these groups (high vs. low ACQ-7 at pre-intervention) in baseline characteristics. Figure 1 illustrates the number of participants with poor, partially, and well controlled asthma at pre and post-intervention time-points. Participants experienced a significant improvement in the activity limitations domain of the ACQ-7 (pre: 1.1 ± 0.2 ; post: 0.5 ± 0.1 , $p = 0.01$, Cohens $d = 0.5$); this difference was above the clinically meaningful cut point of 0.5 in 10 participants (50% of the sample).

Peak RPD decreased from pre to post-intervention (pre: 7.6 ± 1.3 ; post: 5.4 ± 1.6 , $p < 0.01$) and significant improvements were observed in average RPD when comparing pre and post-intervention sessions (pre: 4.2 ± 1.8 ; post: 3.1 , $p = 0.01$, Cohens $d = 0.4$). Figure 2 illustrates the changes observed in average exertional dyspnea during each minute of exercise during the pre and post-intervention sessions. During the pre-intervention session, four participants were unable to

complete the exercise due to volitional fatigue. Thus, only participants who completed the full 20 min session were included in Figure 2 ($n = 16$).

Improvements in exercise enjoyment were observed when comparing pre and post-intervention sessions (pre: 69.5 ± 7.3 ; post: 73.25 ± 6.3 , $p = 0.03$, Cohens $d = 0.8$).

Discussion

The purpose of this study was to determine the impact of a HIIT intervention on asthma control, exertional dyspnea, and exercise enjoyment. Our primary finding was that a 6-week, low volume HIIT intervention led to statistically and clinically significant changes in asthma control. We also found that exertional dyspnea was reduced and exercise enjoyment was improved following the intervention. Together, these findings suggest that HIIT may be implemented and prescribed for adults with asthma.

As hypothesized, HIIT led to improvements in asthma control, and in particular, it led to improvements in the activity limitations domain of the ACQ-7. This is in line with previous research examining changes in asthma control following exercise training. Specifically, following a 12-week moderate intensity exercise training program among adults with asthma ($n = 18$), ACQ scores improved from 1.3 (± 0.19) to 0.72 (± 0.17), while a study of overweight adults with asthma ($n = 55$) found that 69% of participants experienced improvements in asthma control over 12 weeks of moderate intensity exercise training (17). In our study, ACQ improved from 0.8 ± 0.6 to 0.5 ± 0.4 , and 35% of the sample has clinically meaningful improvements. This is important as the majority of previous research has examined the impact of larger volume interventions, that is, exercise sessions are typically longer (e.g. ≥ 30 min) and the length of the intervention is greater (> 12 weeks) (4,17,18).

Of note, the decline in FEV_1 following exercise did not change from pre to post-intervention; we may have been underpowered to detect differences in this measure. However, we did see improvements in the activity limitations item, indicating that improvements in exercise capacity likely allowed participants to perform strenuous daily activities with greater ease. The improvements observed in our study occurred following only 6-weeks of exercise training that consisted of one hour per week of exercise. Thus, adults with asthma who wish to improve asthma control but indicate that time is a barrier to adopting exercise, could be advised to perform HIIT instead of traditional moderate intensity exercise.

We also hypothesized that RPD would decrease due to desensitization to exertional dyspnea symptoms due to repeated exposure to HIIT. Our data suggest that peak RPD and average RPD improved from pre to post-intervention, confirming that repeated exposure to a stimuli (i.e. dyspnea among adults with asthma) may result in a desensitization to that stimuli (11,19). These findings are also in line with previous literature reporting an improvement in exertional dyspnea (using the Medical Research Council dyspnea scale) from 2.58 (± 0.69) to 1.37 (± 1) over an 8 week moderate continuous exercise intervention (20). It is important to note that the improvements observed in RPD may also be due to improved cardiorespiratory fitness. That is, the same exercise workload served as less of a stimuli for dyspnea as cardiorespiratory fitness improved. Future research designs could include a mid-point assessment to increase the dose; however, our study was only six weeks in duration and mid-point improvements would likely be minimal. Regardless of whether the improvements were due to changes in cardiorespiratory fitness, it appears that HIIT would allow adults with asthma to perform daily activities that require higher intensities at a lower level of perceived dyspnea. This is important for asthma related quality of life and overall perceptions of asthma control (21).

Finally, our hypothesis that the intervention would improve exercise enjoyment was also confirmed (20). These improvements may have occurred as a result of an improvement in cardiorespiratory fitness, similar to what has been reported in previous literature (18). For example, a reduction in dyspnea and asthma-related symptoms during exercise may contribute to greater exercise enjoyment among adults with asthma. Improvements in exercise enjoyment has important implications for increasing exercise adherence among this population, given the strong association between exercise enjoyment and future exercise participation (22). Improving exercise adherence would have an important impact on health, asthma control, and asthma related symptoms among adults with asthma.

The results of the present study should be interpreted in light of the following limitations. First, the majority of participants in the present study had well controlled asthma and thus, the generalizability of these findings among adults with less controlled asthma is limited. Future research on more severe and poorly controlled adults with asthma may show even greater improvements. Second, the present study did not include a control group and as such, future research should conduct a larger scale randomized control trial in order to better determine the benefits

of HIIT on asthma control. Despite these limitations, these findings offer promise for the implementation of HIIT among young adults to help improve asthma control and asthma symptoms.

In conclusion it appears that a 6-week, low volume HIIT intervention leads to improvements in asthma control, exertional dyspnea, and exercise enjoyment in adults with asthma. These findings suggest that clinicians and allied healthcare professionals working with adults with asthma can counsel patients on incorporating HIIT, if preferred. Further work is needed to better understand differences in adherence to HIIT versus moderate intensity continuous exercise programs in adults with asthma.

Declaration of interest

The authors have no conflicts of interests to disclose.

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