



Subjective responses to Sprint Interval Exercise in adults with and without Exercise-Induced Bronchoconstriction

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To cite this article: Joshua Good & Shilpa Dogra (2017): Subjective responses to Sprint Interval Exercise in adults with and without Exercise-Induced Bronchoconstriction, Journal of Asthma, DOI: 10.1080/02770903.2017.1391282

To link to this article: <http://dx.doi.org/10.1080/02770903.2017.1391282>



Accepted author version posted online: 12 Oct 2017.



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RUNNING HEAD: Subjective responses to sprint interval exercise

Subjective responses to Sprint Interval Exercise in adults with and without Exercise-Induced Bronchoconstriction

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Word Count

Abstract: 238

Manuscript: 3858

Keywords: Asthma, bronchial hyper-reactivity, high intensity exercise, exercise, cardiorespiratory fitness, sprint interval training

Abstract

Objective: Little is known of the subjective response to exercise that involves short “all out” bursts of effort, separated by recovery periods (sprint interval exercise (SPRINT)) among adults with exercise-induced bronchoconstriction (EIBC). The purpose of this study was to compare subjective responses to SPRINT and moderate intensity continuous exercise (MOD) among adults with EIBC, and to compare these responses between adults with EIBC and those without EIBC. *Methods:* Eight adults (22.3 ± 3.0 years) with EIBC, and eight adults (22.3 ± 3.0 years) without EIBC completed a SPRINT (4x30 second sprints separated by 4.5 minutes of active

recovery) and MOD (20 minutes at 65% peak power output) session in random order. Self-reported affect, perceived breathlessness, and perceived exertion were recorded throughout exercise using validated scales. Enjoyment was assessed following exercise. *Results:* Differences between SPRINT and MOD were observed such that affect and perceived breathlessness were worse during the initial stages of SPRINT than MOD; however differences disappeared by the end of exercise. Enjoyment was similar for SPRINT and MOD in the EIBC group (SPRINT: 72.9 ± 20.0 vs. MOD: 79.5 ± 20.5 , $p=0.25$), and between groups for SPRINT and MOD. *Conclusions:* Perceived breathlessness may impact affect during the early stages of exercise among those with EIBC. Post-exercise enjoyment appears to be similar between SPRINT and MOD. Future research is needed to better understand the relationship between ventilation patterns, exercise intensity, and enjoyment of exercise among those with EIBC.

INTRODUCTION

Exercise induced bronchoconstriction (EIBC) is a transient narrowing of the airway associated with coughing, wheezing, shortness of breath and discomfort as a result of exercise. It may be a significant barrier to the adoption or maintenance of regular physical activity [4]. Improving physical activity levels is important for those with asthma, as studies have shown that exercise leads to improvements in aerobic fitness [5-8], the number of symptom free days [5, 6], quality of life measures [5, 8], and a reduction in the number of hospital visits [9]. *Enjoyment*, an optimal psychological experience that leads to pursuing an activity for its own sake and is associated with positive affective experiences [10], and *affect*, the experiential component of all valenced (i.e., 'good' or 'bad') responses, including emotions and moods [11], are important factors when determining an appropriate exercise prescription, as they impact

long-term adherence to exercise. Specifically, affect during an acute bout of exercise is predictive of future physical activity behaviour [12, 13]. Studies on high intensity interval exercise (HIGH), utilizing alternating 1:1 periods of high and low intensity exercise, have found higher affect during HIGH [14, 15] and lower enjoyment [16] compared to moderate intensity continuous exercise (MOD). Enjoyment appears to depend on the relative intensity of exercise, as MOD protocols that are higher in intensity are associated with less enjoyment [15]. Among those with EIBC, interval exercise allows for minute ventilation (V_E) to recover, which may reduce breathlessness and thus lead to higher affect and enjoyment. Previous research from our laboratory found that participants with EIBC had higher affect scores during HIGH (alternating 1 minute intervals at 90% peak power output (PPO) and at 10% PPO) compared to MOD (20 minutes at 65% PPO), but no differences in enjoyment [17].

Sprint interval exercise (SPRINT), which involves short, ‘all out’ sprints separated by longer recovery periods, is becoming a popular form of exercise, as it saves time compared to MOD and HIGH while still providing similar benefits [18-22]. However, it is not known whether the longer recovery periods during SPRINT would allow V_E to recover further, thus limiting breathlessness and further increasing affect and enjoyment among those with EIBC. The primary purpose of this study was to compare affect during exercise and enjoyment post-exercise, in the context of ventilatory measures, during SPRINT and MOD in adults with EIBC. A secondary purpose was to compare these subjective responses between those with EIBC to a healthy comparison group. We hypothesized that perceptions of dyspnea would be greater, affect would be lower, and post-exercise enjoyment would be lower for SPRINT compared to MOD due to the high V_E during SPRINT. We also hypothesized that individuals with EIBC would experience

higher perceptions of dyspnea and lower affect during both SPRINT and MOD compared to the healthy comparison group.

METHODS

Participants

Inclusion was limited to adults aged 18-44 years who engaged in regular physical activity (≥ 150 minutes of moderate to vigorous intensity exercise per week). Adults over 44 years of age were excluded to reduce the possibility of the presence of chronic obstructive pulmonary disease, and inactive adults were excluded to ensure participants could complete SPRINT. Inclusion in the *EIBC group* was further limited to those with self-reported physician diagnosed asthma and/or EIBC, current prescription for short-acting bronchodilator, and positive response to a eucapnic voluntary hyperpnea challenge (described elsewhere [23, 24]). Those with a previous physician diagnosis of asthma or EIBC, and a positive response to the eucapnic voluntary hyperpnea challenge were excluded from the *comparison group*. All participants provided written consent prior to beginning the study. The study was approved by the University of Ontario Institute of Technology's Research Ethics Board.

Study Design

This was a randomized cross-over study comparing those with and without EIBC. All participants completed three sessions, each separated by a minimum of 48 hours to reduce the impact of a refractory period following EIBC. In *session 1*, participants completed an incremental to maximal intensity exercise test. *Sessions 2 and 3* were the exercise sessions completed in random order.

Reported Measures

Demographics: Basic demographic information regarding age, sex, and perceived health was collected during the first session through a questionnaire.

Mini Asthma Quality of Life Questionnaire (mini-AQLQ) was completed during session 1. This questionnaire consists of 15 questions regarding symptoms, activities, emotions and environment in relation to overall quality of life. Each question is scored on a scale of 1-7, with higher numbers indicating a better quality of life. The score for each question is averaged yielding a total score, with 7 as the highest possible score. In addition, the mini-AQLQ can be divided in to four domains (symptoms, activity limitation, emotional function, and environmental stimuli), also with 7 as the highest possible score. The mini-AQLQ has been shown to have good reliability (Intraclass correlation coefficient=0.83) as well as validity, measured by responsiveness ($p=0.0007$) [25]. A cut-point of 5.4 on the mini-AQLQ has been suggested, with values <5.4 being related to worse asthma control and quality of life [26].

Affect: Participants were asked to report on their general affective valence (pleasure/displeasure) based on the One-Item Feelings Scale (AFF) [27]. This scale ranges from -5 to +5 (very bad to very good). Participants were instructed “While participating in exercise, it is common to experience changes in mood. For example, one might feel good and bad a number of times during exercise. When asked, please tell me how you feel in the current moment using the scale.”. AFF was reported each minute during SPRINT and MOD. An overview of when each measurement was assessed during SPRINT and MOD sessions is shown in Figure 1.

The Physical Activity Enjoyment Questionnaire was completed 10 minutes following the completion of the SPRINT and MOD session. This questionnaire uses 18 questions to assess the

enjoyment experienced during exercise and has demonstrated high reliability and validity [28].

This questionnaire was modified by removing the following question “I am very absorbed in this activity – I am not very absorbed in this activity.” This was done due to the questionnaire being completed 10 minutes following exercise so the question was irrelevant. Each question is scored on a 7-point bipolar scale with a maximum score of 119. This modified version of the *Physical Activity Enjoyment Questionnaire* has been used previously for HIGH; however, validity and reliability for this modified version have not been assessed [15, 17]. Following the final session, participants were also asked if they preferred SPRINT or MOD.

Rating of Perceived Dyspnea and Exertion: Participants pointed to a number on a scale of 0 to 10 for their Rating of Perceived Dyspnea (RPD) which corresponds to their perceived feeling of dyspnea (shortness of breath). The RPD has been shown to be a valid and reliable measure [29]. Participants also reported their Borg Rating of Perceived Exertion (RPE) on a scale of 6-20. Participants were asked to think about exertion in their legs because RPD referred specifically to breathlessness. The RPE scale is considered a valid measure of exercise intensity [30]. RPD and RPE were also asked every minute during SPRINT and MOD.

EIBC symptoms: Participants were asked if they were feeling signs/symptoms typical of EIBC. These included sore throat, coughing, wheezing, light headedness, and phlegm in their throat. If they responded affirmatively that they were feeling a symptom, they were asked to rate this on a scale of 1-5 (from mild to severe) four times throughout SPRINT and MOD (minutes 1.5, 6.5, 11.5, and 16.5).

Late Phase Asthma Symptom Questionnaire: Only participants in the EIBC group were given this questionnaire. This questionnaire was created to assess any late phase asthma symptoms that

may occur as a result of exercise testing up to 48 hours post-exercise. If the participant experienced any of coughing, wheezing, shortness of breath, sore throat, a dry, itchy throat, chest tightness, increased mucus, sleep disturbances or other symptoms they were asked to rate it from 1-5 (mild to severe) and indicate the time point of occurrence.

Physiological measures

Breathing Reserve (BR): Expired gas was collected through a pneumotachograph and analyzed using an automated gas collection system (Parvo Medics 2400, USA). Data were linearly interpolated to yield second-by-second values and V_E was analyzed. Maximum voluntary ventilation was calculated based on American Thoracic Society guidelines using 40 times the baseline forced expiratory volume in one second from the maximal exercise test [31]. BR was calculated as follows:

$$BR = 100 [\text{maximum voluntary ventilation} - V_E] / \text{maximum voluntary ventilation}$$

BR is typically $\geq 20\%$ in healthy adults at peak exercise. A BR of $<20\%$ may be an indication of a pulmonary disease [32]. BR was calculated at 0.5, 5.5, 10.5, and 15.5 minutes (corresponding with peak V_E observed at the end of each sprint), by averaging the values of the five seconds surrounding each time point. BR was used as an objective measure of exercise intensity.

Methodology

Maximal Exercise Test: Participants pedaled on a cycle ergometer at 80 rpm and completed an incremental to maximal exercise test. PPO was recorded as the final stage completed.

Exercise Sessions: Participants were familiarized to the cycle ergometer and all scales prior to the start of SPRINT and MOD. The SPRINT and MOD protocols started with a two minute warm-up between 50 and 60 Watts. For the MOD session, following the warm-up, participants

cycled at 80 rpm at 65% PPO for 20 minutes. Following the MOD session, participants completed a 5 minute cool down at a self-selected cadence and resistance. For the SPRINT session, five seconds prior to the end of the warm-up, participants were instructed to cycle as fast as possible with no resistance. Participants then completed the 30 second sprint (at 0.075kg/kg of body weight resistance) with time updates occurring with 20, 10, and 5 seconds left in the sprints. No other encouragement was provided during the sprints. Participants completed four sprints with 4.5 minutes of unloaded cycling at 40 to 60 rpm between sprints (20 minutes of total exercise). Following SPRINT, no additional cool-down was completed, because following the final sprint the 4.5 minutes of unloaded cycling served as a cool-down. The SPRINT session was based on previous research using similar protocols [18, 19].

For statistical analysis of RPE, RPD, and AFF, time points corresponding with immediately following and three minutes following each sprint were used.

Statistical Analysis

Means and standard deviations were calculated for all continuous variables to describe the sample. Three factor (exercise protocol (SPRINT or MOD) x measurement time-point during or following exercise x EIBC status (with or without EIBC)) repeated measures analysis of variance tests were used to determine if there were differences within and between exercise protocols for AFF, RPD, RPE, and BR. When sphericity had been violated, Greenhouse-Geisser corrections were used. Interactions with $p \leq 0.10$ were examined further to determine where differences occurred. All statistics were done in IBM SPSS statistics 23.0 (Armonk, NY) and statistical significance was declared at $p < 0.05$. Effect sizes were calculated in G*Power 3.0.10 to report the magnitude of difference between SPRINT and MOD enjoyment scores.

RESULTS

Of the eleven eligible participants with EIBC and the eleven participants in the comparison group, three from each group were excluded due to an inability to complete SPRINT and/or MOD, or dropped out due to injuries not related to the study, or due to a lack of time. Three of eight participants with EIBC had a score <5.4 on the mini-AQLQ (5.6 ± 1.2). Based on the symptoms score (5.4 ± 1.5), activity limitation score (6.4 ± 0.8), emotional function score (5.0 ± 1.9), and environmental stimuli score (5.4 ± 1.2), participants in the current study were not limited by their asthma. Additional sample characteristics can be found in Table 1.

Affect

There was no significant three way interaction between exercise protocol, measurement time-point, and EIBC status for AFF ($p=0.86$). There was a significant two way interaction between exercise protocol and measurement time-point ($p=0.004$), but not between measurement time-point and EIBC status ($p=0.14$) or exercise protocol and EIBC status ($p=0.60$). The minimum AFF reported was similar between the EIBC and comparison group for MOD (-1.8 ± 2.8 vs. 0.0 ± 2.8 , $p=0.23$) and SPRINT (-2.1 ± 1.9 vs. -0.3 ± 3.1 , $p=0.16$, Figure 2A). When the groups were combined, minimum affect did not differ between SPRINT and MOD (-1.2 ± 2.6 vs. -0.8 ± 2.8 , $p=0.71$).

Physical activity enjoyment

Enjoyment, as per the *Physical Activity Enjoyment Questionnaire*, was similar for SPRINT compared to MOD in both the EIBC (72.9 ± 20.0 vs. 79.5 ± 20.5 , for SPRINT and MOD, respectively, $p=0.25$, $d=0.33$) and the comparison (81.0 ± 14.7 vs. 86.4 ± 14.2 , $p=0.07$, $d=0.37$)

group. However, 14/16 participants reported lower enjoyment scores for SPRINT than MOD. Enjoyment was similar for MOD ($p=0.44$) and for SPRINT ($p=0.37$) when comparing the EIBC and the comparison group. Ten of the 16 participants (4/8 with EIBC and 6/8 in the control group) reported that they preferred MOD compared to SPRINT.

Perceived Breathlessness and Exertion

There were no significant three way interactions between exercise protocol, measurement time-point, and EIBC status for RPD ($p=0.89$) or RPE ($p=0.56$). As expected, there were significant two way interactions between exercise protocol and measurement time-point ($p<0.001$ for both RPD and RPE).

For RPD, there were no significant two way interactions between exercise protocol and EIBC status ($p=0.23$) or between measurement time-point and EIBC status ($p=0.27$). Peak RPD was similar between the EIBC and comparison group for MOD (6.5 ± 2.4 vs. 6.1 ± 2.4 , $p=0.76$) and SPRINT (7.9 ± 1.4 vs. 6.6 ± 1.8 , $p=0.13$). Significant differences in RPD between SPRINT and MOD in both the EIBC and comparison group were observed at some time points, as shown in Figure 2B.

For RPE, the interaction between measurement time-point and EIBC status was not significant ($p=0.080$). Peak RPE was similar between the EIBC and control groups for MOD (17.4 ± 2.6 vs. 16.9 ± 1.4 , $p=0.64$) and SPRINT (16.9 ± 2.4 vs. 17.5 ± 2.6 , $p=0.62$, Figure 2C).

Breathing reserve

There was no significant three way interaction between exercise protocol, measurement time-point, and EIBC status for BR ($p=0.89$). There was a significant two way interaction between exercise protocol and measurement time-point for BR ($p<0.001$). There were no significant two

way interactions between measurement time-point and EIBC status ($p=0.082$) or between exercise protocol and EIBC status for BR ($p=0.89$).

Minimum BR was significantly less in the EIBC group during MOD compared to the comparison group (41.5 ± 6.9 vs. 49.0 ± 6.2 , $p=0.038$, Figure 2D). There was no significant difference in minimum BR between the EIBC and comparison groups during SPRINT (33.5 ± 8.2 vs. 32.4 ± 21.1 , $p=0.78$). Minimum BR was significantly less during SPRINT than MOD in the comparison group ($p=0.029$).

EIBC symptoms

The cumulative frequency for each sign or symptom is shown in Figure 3. When participants with EIBC reported a symptom, the average severity was not significantly different for SPRINT and MOD (2.0 ± 0.9 vs. 1.9 ± 1.3 , $p=0.71$). The number of unique participants that reported each symptom is shown in Figure 4A.

The frequency of late phase asthma symptoms experienced is shown in Figure 4B. When participants experienced a symptom, the average severity was not significantly different for SPRINT and MOD (1.8 ± 0.8 vs. 1.5 ± 0.9 , $p=0.21$).

DISCUSSION

We aimed to determine if perceptions of breathlessness, exertion, affect, and enjoyment were different during SPRINT and MOD sessions both among those with EIBC, and comparing those with EIBC to healthy adults. The primary results of this study indicate that among active adults with EIBC, breathlessness influences affect during the early stages of exercise (with worse RPD and AFF during SPRINT than MOD); these differences disappear later in exercise, likely due to the relatively high intensity of the MOD protocol chosen in the current study. A secondary

finding is that regardless of EIBC status, enjoyment appears to be similar for SPRINT and MOD. Finally, significant differences in subjective responses were not observed between those with and without EIBC for either SPRINT or MOD. These findings have implications for exercise prescription in adults with EIBC.

Affective response during exercise

We hypothesized that AFF would be worse during SPRINT than MOD in the EIBC group, and worse among the EIBC group than the comparison group. AFF was worse during SPRINT than MOD; however, only during the early stages of exercise. We did not find differences between groups for AFF. In general, a decline in affect was observed for both groups during SPRINT and MOD (Figure 2A). AFF during exercise has been reported to decrease as exercise intensity increases [34]. Previous studies have reported a decrease in affect across multiple sprints during SPRINT; however, these studies did not compare to MOD [35, 36]. In a study by Saanijoket al., lower affect was observed throughout SPRINT compared to MOD among sedentary, middle-aged men [37]. The study utilized 60% of PPO for the MOD protocol, whereas we used 65% PPO in the current study. Furthermore, the recovery intervals were 30 seconds longer in the present study. Significant differences in affect observed between SPRINT and MOD among the EIBC group may be related to the high V_E at the end of each sprint. Exercise above the ventilatory threshold, specifically increasing blood lactate levels, has been shown to be negatively correlated with affect [38, 39]. During our MOD protocol, within 10.5 minutes, participants were exercising at intensities near or above their ventilatory threshold (as evidenced by V_E), thus lactate accumulation may have contributed to the lack of difference observed in affect between SPRINT and MOD after sprint three and four. Future research should assess

protocols using different MOD intensities. A lower intensity MOD protocol may lead to less breathlessness, and better affective responses.

Enjoyment of SPRINT and MOD

Based on previous reports of the strenuous nature of SPRINT and feelings of light headedness and nausea during SPRINT, it was hypothesized that enjoyment for SPRINT would be lower than MOD [40-42]. Our results indicate that enjoyment was similar between the two exercise sessions; however, 14 of the 16 participants reported higher enjoyment following MOD than SPRINT, and 10 of 16 participants preferred MOD to SPRINT. Previous research has found that high intensity interval cycling and running may be more enjoyable than MOD [14-17]. However, these studies used *near maximal* intensity intervals while we utilized *supramaximal* intervals. Previous studies using supramaximal intervals have reported higher enjoyment for SPRINT compared to MOD [43], no significant differences [44, 45], or even lower enjoyment [46]. These studies were in different populations, used different modes of exercise, and used different protocols (interval lengths and intensities), which may account for differences observed. Previous studies reporting enjoyment following Wingate-based SPRINT have not compared to MOD but have compared the effect of music and encouragement on enjoyment. The enjoyment scores for SPRINT reported in the current study (76.9 ± 17.4 out of 119) are similar to those reported by Stork et al. (>80 out of 126) and Tritter et al. (72.4 ± 18.0 out of 126 when no encouragement was given) [35, 36]. These results indicate that the specific protocol chosen and other external factors such as music and encouragement may be important in predicting enjoyment. When examining other interval protocols, previous research by O'Neill et al. found

similar enjoyment between HIGH and MOD protocols in a sample of adults with EIBC [17]. Future research is needed to compare SPRINT and HIGH to a less intense MOD protocol.

Perceptions of dyspnea and exertion

We hypothesized that RPD would be worse during SPRINT than MOD in the EIBC group, and worse among participants with EIBC than those without EIBC. This was partially confirmed with significantly higher breathlessness observed immediately following sprint one, two, and three in SPRINT compared to MOD among those with EIBC (Figure 2B) and immediately following sprint one and two in the comparison group. However, differences disappeared by the end of exercise. In older adults with chronic obstructive pulmonary disease, lower dyspnea scores have been reported during HIGH compared to MOD [47]. To the best of our knowledge, perceived dyspnea has not been studied using protocols of supramaximal intensity intervals in comparison to continuous exercise in those with EIBC. Previously, V_E has been shown to be a predictor of dyspnea in adults with asthma during maximal exercise testing [48]. In the current study, BR was significantly lower at the end of each sprint compared to corresponding time points during MOD, potentially contributing to higher RPD (Figure 2D). The minimum BR was also lower in the EIBC group than the comparison group during MOD but not SPRINT. This highlights the potential importance of the recovery periods during SPRINT in limiting excess V_E , leading to higher breathlessness.

Similar to perceived dyspnea, RPE was significantly higher immediately following sprints one and two compared to MOD in the EIBC group (Figure 4C). RPE may have been significantly higher during SPRINT only following sprint one and two because lactate may have accumulated throughout MOD, which has been correlated with RPE [39]. Previously, RPE has

been reported to be higher during SPRINT compared to MOD [37]. As previously mentioned for affect, differences may be due to the intensity of the MOD protocol used. It was also observed that RPE was similar between the EIBC and comparison groups for SPRINT and MOD. This indicates that both groups exerted themselves similarly, so differences in affect or breathlessness would be related to EIBC, not effort. These results indicate that a balance of recovery periods and higher intensity exercise may play an important role in limiting perceptions of breathlessness.

Signs/symptoms during exercise

A sore throat, coughing, wheezing, and phlegm in the throat were experienced more frequently during SPRINT than MOD, likely due to high peak V_E achieved during SPRINT. The increased symptoms may be caused by increased drying of the airway associated with high V_E [49]. The increased occurrence of these symptoms may lead to less enjoyment during exercise. Light headedness has been reported previously during SPRINT [40-42]. Symptoms such as nausea and light headedness may lead to lower enjoyment when compared to MOD. Future research should examine if V_E is related to a higher prevalence of symptoms during exercise and if symptoms experienced are related to objective measures of EIBC.

Limitations

There are some limitations to the current study. First, we may have been underpowered to detect differences in enjoyment and affect; however, given the homogeneity within and between groups, the trends observed are informative. Second, participants were breathing through a mouthpiece during exercise; this may have influenced subjective responses. However, during exercise at high intensities, V_E is predominately through mouth breathing, therefore the impact of

the mouthpiece was likely minimal. Thirdly, participants in the current study were active and therefore, may have been accustomed to high V_E or perceptions of dyspnea. Finally, the results of the current study may not be generalizable to inactive adults with EIBC, or to outdoor exercise where other factors such as pollution, allergens, and cold air may trigger bronchoconstriction in addition to exercise.

In conclusion, SPRINT and MOD are associated with similar levels of enjoyment and affect among adults with and without EIBC. Future research using larger samples is needed to better understand the relationship between V_E patterns during exercise and the subjective response among those with EIBC.

Declaration of interest: The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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FIGURE CAPTIONS

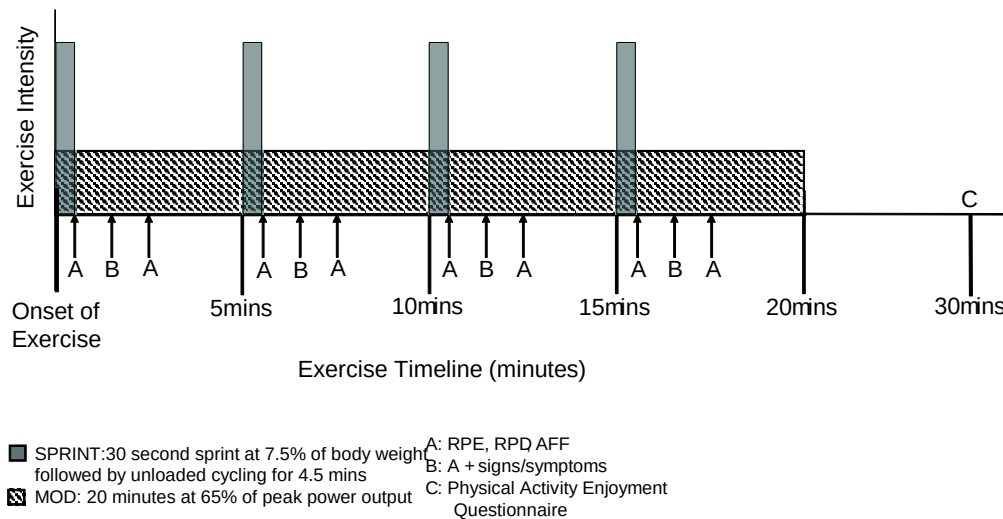


Figure 1 – Timeline of reported measurements assessed during the SPRINT and MOD sessions

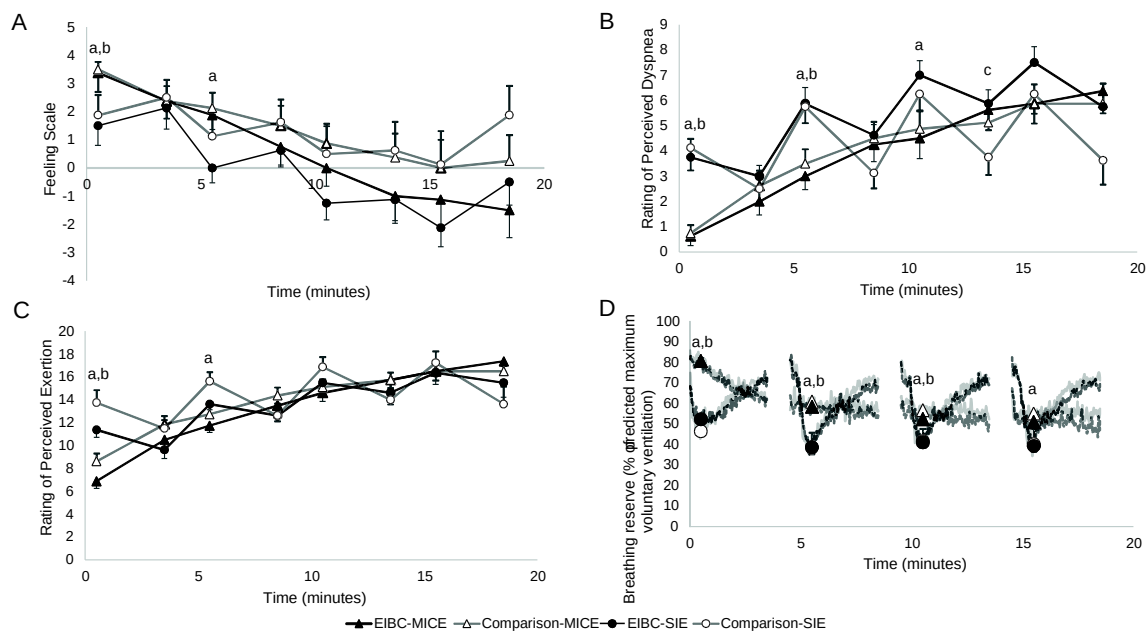


Figure 2 – Acute Subjective and Respiratory Response to SPRINT and MOD in adults in the EIBC and comparison group

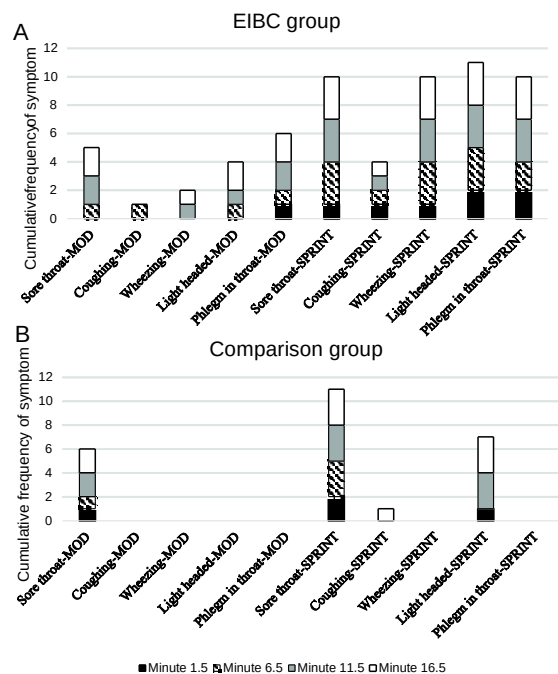


Figure 3 – Frequency of each symptom experienced during SPRINT and MOD for the EIBC group (A) and the comparison group (B)

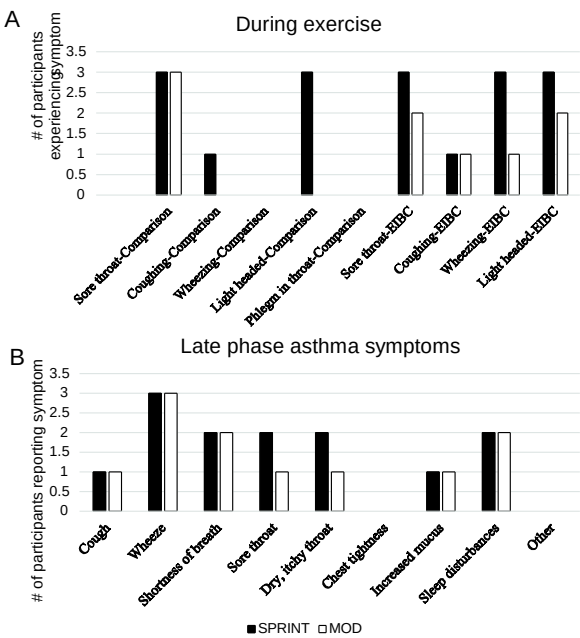


Figure 4 – Symptoms reported by EIBC group during and 48 hours post SPRINT or MOD

Table 1: Sample characteristics for those with EIBC and the Comparison group

	With EIBC (n=8)	Comparison group (n=8)
Sex (# of males)	6	6
Age (years)	22.3 $\pm$ 3.0	22.3 $\pm$ 3.0
BMI (kg/m ²)	26.5 $\pm$ 3.3	24.8 $\pm$ 4.5
mini-AQLQ	5.6 $\pm$ 1.2	N/A

No significant differences were observed between groups