

**High-intensity interval training in people with mild multiple sclerosis: a mixed-methods feasibility study**

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# **"I didn't think I'd be able to do that" high-intensity interval training in people with low multiple sclerosis disability: A mixed-methods feasibility study**

## **Abstract**

**Background/Aims:** High-Intensity interval training has received increased attention as a mode of exercise, including as a therapy in clinical populations.

This study aimed to investigate the acceptability of a high-intensity interval training intervention in people with low multiple sclerosis-related disability.

**Methods:** Participants attended two sessions per week for the 6-week intervention. Each session consisted of 6-to-10 sets of 60 seconds high-intensity intervals interspersed with 120 seconds recovery. The acceptability, intervention adherence, and safety of the high-intensity interval training protocol and estimates of treatment effects (fitness, physical activity levels, fatigue, and quality of life) were used to determine intervention feasibility. We used qualitative interviews to explore the acceptability of the intervention.

**Results:** Eleven people with low-level multiple sclerosis-related disability consented to participate in a 6-week high-intensity interval intervention. One participant dropped out of the intervention. The participants expressed apprehension before the intervention but attendance at the exercise sessions was high (87%). Participants experienced some symptom exacerbation following sessions, although none were serious. Improvements were seen in fitness, physical activity, fatigue, and health-related quality of life.

**Conclusions:** The study findings suggest that high-intensity interval training is acceptable, safe, and may offer disease-related benefits for the participants. Participants did experience some symptom exacerbation and further studies are needed to determine the long-term appeal of high-intensity interval training for people with low multiple sclerosis-related disability.

**Keywords:** exercise, feasibility, fitness, high-intensity, multiple sclerosis, qualitative.

## **Introduction**

Exercise has the potential to help people with multiple sclerosis (pwMS) better manage their condition. Indeed, research has shown that moderate-intensity supervised exercise (aerobic and strength) training can improve function and help manage symptoms in people with mild to moderate MS (Kalb et al. 2020)(Motl and Pilutti 2012)(Carter et al. 2014)(Latimer-Cheung et al. 2013). Evidence also suggests that exercise might even have a disease-modifying effect (Dalgas et al. 2019). Additionally, there is limited, but promising evidence for the benefits of exercise training in persons with severe MS-related disability (Edwards and Pilutti. 2017). Cardio-respiratory fitness is an important marker for MS, as it has been shown to be inversely correlated with disease disability, with cardio-respiratory fitness decreasing as disability and fatigue increase (Heine et al. 2015). Therefore, maintaining or increasing physical activity and the cardio-respiratory fitness of pwMS and exploring the effects on disease progression, symptom prevention, and general health is a priority.

The MS-specific physical activity guidelines have been developed for adults (aged 18-64 years) with mild to moderate MS-related disability and recommend moderate-intensity aerobic exercise and strength training (Latimer-Cheung et al. 2013). Despite the published guidelines, more information is required on the most effective dose to achieve optimal improvements in function and management of the disease and avoid harm (Collett et al. 2010). High-intensity interval training (HIIT) is a mode of exercise that has been growing in popularity, including in clinical populations (Smart 2013). HIIT is characterised by short bursts of vigorous effort followed by periods of rest or low-intensity exercise (Gibala et al. 2012). HIIT is not included in the exercise prescription recommendations for pwMS.

A systematic review recommended HIIT as a possible effective intervention for pwMS concluding HIIT as safe and effective at improving fitness (Campbell et al. 2018). Additionally, exercising more intensively for shorter durations has been reported to be more enjoyable (Jung et al 2015). While this data is encouraging, the evidence of the benefits of HIIT for pwMS is in its infancy, and further research is needed to confirm whether pwMS enjoy HIIT and feel it is tolerable. Understanding the feasibility of HIIT is fundamental for clinical populations such as MS. Given the nature of MS, it is crucial to consider the impact HIIT has on factors such as fatigue, increased temperature, and exacerbation of symptoms. It has been reported that 60-80% of pwMS experience a reversible occurrence of symptoms in situations that increase their body temperature (Uthoff Phenomenon), for example, vigorous exercise (Döring et al. 2012). Additionally, understanding participant's experiences and perspectives of engaging with programmes is important to inform future interventions and health care strategies (Crank et al. 2017). To our knowledge, no research has explored the experiences of pwMS participating in HIIT.

The primary aim of this study was to examine the acceptability of HIIT as an intervention for people with mild MS-related disability. Acceptability was explored through semi-structured qualitative interviews. The secondary aim was to observe whether HIIT is feasible for people with mild MS-related disability. Feasibility was defined in terms of participant's attendance, intervention adherence, safety, and estimation of intervention effects.

People with mild MS-related disability were chosen as HIIT is not part of the recommended exercise prescription guidelines for pwMS (Latimer-Cheung et al. 2013). We therefore felt it was important to determine the acceptability of HIIT initially in people with mild disability. Additionally, Initiation of exercise early in the disease course

has been identified as a focus area in research for people with MS (Riemenschneider, 2018). Riemenschneider and colleagues state that exercise is often initiated at a late disease stage and initiating exercise earlier may have neuroprotective and disease-modifying effects (Riemenschneider, 2018).

## **Methods**

### ***Design***

This was a 6-week single group, non-randomised, feasibility study. A mixed-methods approach was used to determine acceptability and feasibility. NHS Ethical approval was obtained from the National Research Ethics Service Committee Yorkshire and the Humber (REF 15/YH/0441).

### ***Participants and Recruitment***

Recruitment was conducted via neurological clinics at the collaborating hospital. The neurological consultants and research nurses identified individuals who met the inclusion criteria: (1) males and females aged between 18 and 65 years of age; (2) low MS-related disability; (3) clinical diagnosis of MS for more than three months; (4) not had more than one relapse in the previous year. Exclusion criteria for the study included: (1) Failure to meet any of the inclusion criteria; (2) comorbid conditions or injury that impairs their ability to exercise. Participants were then provided with a patient information sheet and completed a permission to contact form. The study coordinator conducted a brief telephone call to confirm eligibility, answer questions regarding the study, and schedule an initial meeting. To determine the disability level of the participants, the Patient Determined Disease Steps (PDDS) measure was used. The PDDS is a short, simple questionnaire that has a strong correlation with the Expanded

Disability Status Scale, a clinician-reported measure of disability (Learmonth et al. 2013). The criterion for low MS-related disability was 0-1 (mild disability). At the initial meeting, participants were introduced to the study laboratory and taken through the study protocol. Written informed consent was taken during this meeting.

### ***Baseline Assessment***

To establish cardio-respiratory fitness, participants performed a  $VO_{2peak}$  test on a cycle ergometer under the supervision of a trained exercise scientist.  $VO_{2peak}$  was used because symptoms of MS can affect a person's ability to achieve a true  $VO_{2max}$  (Langeskov-Christensen et al. 2014). The gas exchange measurement was conducted breath-by-breath using telemetric spirometry (Ultima, MedGraphics); heart rate was measured by Polar System. The exercise test began with pedalling at 60-65 revolution per minute (rpm) with a power output set to 30W. After the first four minutes, the power output increased by 15W every 2 minutes. The test was conducted to volitional exhaustion. Heart rate and rate of perceived exertion (RPE) were collected at the end of each minute and the highest  $VO_2$  (ml/kg/min) observed before reaching volitional exhaustion determined  $VO_{2peak}$ . This test protocol has been used previously in pwMS (Motl and Fernhall 2012). Three questionnaires were administered to the participants to determine the impact of the exercise interventions on physical activity level (Godin Leisure Time Questionnaire (Godin and Shepard 1985)), fatigue (modified fatigue impact scale (Fisk et al. 1994)), and health perception (MSQoL-54(Vickrey 1995)). The Godin Leisure Time Questionnaire (GLTEQ) is a self-administered two-item measure of usual physical activity with no specified time component (Motl and Snook 2008). There is evidence that the GLTEQ is a valid measure for the physical activity levels of PwMS (Sikes et al 2019). The modified fatigue impact scale (MFIS) is a shortened

version of the original, 40-item Fatigue Impact Scale (Fisk et al. 1994). The MFIS has good psychometric properties for people with MS and correlates well with other fatigue measures such as the Fatigue Severity Scale (Khalil et al. 2020). The MSQOL-54 includes both generic and MS-specific quality of life questions (Amato et al. 2001). It has been shown to have high test-retest reliability and construct validity (Ochoa-Morales et al. 2019)

### *Secondary outcome measures*

Changes to cardio-respiratory fitness were measured using the  $VO_{2peak}$  cycle ergometer test. Fatigue and general quality of life questions were used to measure changes to the impact of MS on the patient. Outcomes were assessed at two-time points: at baseline (week 1) and after the follow-up assessment after completion of the 6-week intervention (week 8).

### *Intervention protocol*

Participants attended two sessions per week for the 6-week intervention. Traditional HIT training consists of repeated ‘all-out’ maximal cycling (i.e., Wingate test). This type of training is highly demanding and requires a specialised cycle ergometer, and thus may not be safe or practical for some individuals (Little et al. 2010). The present study followed a protocol adapted from previous research (Hood et al. 2011). The protocol used by Hood and colleagues (2011) kept the training session time low, decreased the absolute intensity of the intervals, but increased the interval duration. The protocol from Hood and colleagues is deemed more suitable for some populations than traditional “all-out” intervals (Hood et al. 2011) and has been used with people with type 2 diabetes (Hood et al. 2011) and in stroke rehabilitation (Boyne et al. 2015). Each session consisted of six to ten sets of 60 seconds high-intensity intervals interspersed

with 120 seconds recovery. The number of repetitions increased each week, starting at six until the participants were able to complete ten repetitions per session. The workload during each interval was set at 80-90% of peak power achieved during the  $VO_{2peak}$  test. This was predicted to elicit 85-95% heart rate maximum in the participants. After each interval, the participant's heart rate and RPE were recorded. After each session, the researcher completed a session feedback form, identifying any events that occurred during the exercise session. At the start of the next session, the feedback form was again used to record any issues that occurred post previous session. Events included any exacerbation of MS symptoms (e.g., fatigue) or any serious adverse events (e.g., hospitalisation).

### ***Acceptability***

Semi-structured qualitative interviews explored the acceptability of the intervention through the participant's perceptions and experiences. At the end of the intervention, each participant was interviewed. Interviews were conducted by the lead researcher, trained in qualitative research. A semi-structured interview schedule was used to ensure consistency across interviews. The interview topics and example questions are provided in table 1. Interviews were conducted over the telephone and were recorded using a digital recording device. Interview length ranged from 14 to 34 minutes, and the mean interview duration was 22.5 minutes.

### ***Feasibility***

To measure feasibility, the research team identified the attrition rate, established by any discontinuation of the intervention or loss to follow up. Attendance at the exercise sessions and compliance to the prescribed intensity were also measured. Compliance to the protocol was defined as; the average heart rate of the high-intensity intervals being



between 85-95% of heart rate maximum.

### *Safety*

Participant safety was assessed by the number of adverse events occurring during the exercise sessions. An adverse event can be serious or non-serious (Niemeijer et al. 2020). A serious adverse event is defined as an event that leads to either death, hospitalisation, or a serious risk of deterioration in health. Other reported adverse events such as pain, fatigue and a fall were defined as non-serious (Niemeijer et al. 2020). A researcher monitored participants throughout the exercise sessions and completed a session feedback form as previously discussed.

### *Qualitative analysis*

Each of the ten interviews was transcribed verbatim. The data was analysed using framework analysis (Ritchie and Lewis. 2003). Framework analysis involves several interrelated but distinct stages (Gale et al. 2013). This methodology is increasingly used in health research, is considered straightforward, and enables the researcher to transparently link results and conclusions back to the original data (Ward et al. 2013). The transcripts were read, before coding, indexing, and charting to create an initial key thematic framework with subthemes. The themes from the transcripts were clustered around the participant's experiences before and after the intervention.

### *Quantitative Analysis*

Statistical analysis was performed using SPSS (version 26). Based on the study's feasibility design with small sample size and no comparison arm, it would not be appropriate to make statistical comparisons of effectiveness. As a result, inferential statistics were not performed. Only descriptive statistics are presented (means, standard

deviations, and mean change with the corresponding 95% confidence intervals (95% CI)). Data for the participant who withdrew were removed from the analysis.

## **Results**

### ***Participants***

In total, eleven participants consented to the study and completed baseline measures. Descriptive characteristics of the participants (10 female and 1 male) at baselines are summarised in table 2.

### ***Qualitative results***

The qualitative findings are presented according to higher-order themes and lower-order themes, in line with the framework analysis technique (Ritchie and Spencer 1994).

The higher order themes were centred around the participant's experiences before, during and after the intervention. These themes contextualise the experiences and perspectives of the participants in the study. These higher and lower order themes are shown in table 3. Direct quotes, with reference to participant number, are presented to illustrate the themes.

#### ***Theme 1: Feelings before the trial.***

Before commencing the study, participants had some doubts about taking part. These doubts came from their low confidence in their ability to complete high-intensity exercise and from the opinions of their family and friends.

The participants had concerns about high-intensity exercise:

Participants discussed having concerns about how their body would react with the high-intensity sessions.

"I fully expected to feel awful and tired, and achy and that I would hate it, and to be totally honest, I didn't think I'd be able to do it. So I kept having this earwig going you're not going to be able to do it, you're going to hurt yourself, this is a bad idea." (P2)

"I was thinking, you know, kind of maybe I'm not up to this." (P3)

"When I started this study I did not feel as though I had the energy levels required for strenuous or even moderate levels of exercise." (P6)

Friends and family had concerns about high-intensity exercise

Some participants discussed friends and family also have concerns for them completing the exercise sessions.

"My mum and dad are very protective. So, they kept saying oh don't overdo it, you'll end up hurting yourself." (P2)

"My friends were concerned. My parents were uneasy about it and thought I should be taking it easy and weren't convinced it was a good idea." (P4)

"My friends were worried I was doing too much." (P11)

Others reported having positive encouragement from friends and family. Normally from an active person.

"A couple of friends have bikes and they say you should come with us, trying to get me to go out." (P1)

"My husband was supportive and keen for me to do it and thought I would enjoy it." (P4)

Participant motivation for taking part

Despite the concerns, participants signed up for the study and reported several different reasons for doing so. These included; the opportunity to improve health, finding an alternative to pharmacological treatment and because the consultant recommended it.

"It's not like you are pumping yourself full of drugs. It's not drugs, it's something completely natural." (P1)

"I just wanted to get fit again, to be honest." (P3)

"I just wanted to feel fitter. So it was an opportunity to actually do something in a controlled environment." (P11)

"The consultant recommended it so I said yes." (P9)

"Well it's just somebody telling you to do exercise that's got a background in MS." (P5)

"I think you always put your trust in the people who are supposed to know more than you. So if he recommended it regardless of my personal view on something I think I'd probably give it a crack." (P2)

### *Theme 2: Positive impact of the HIIT intervention*

Participants reported positive and negative impacts from engaging in the study. Positive effects included improvements in energy levels and psychological improvements (such as increased).

#### Increased energy levels

Participants discussed how the HIIT intervention improved their energy and perceived levels of fatigue.

"I'm like I'm awake, I'm not tired, you know. So it's totally overthrown my fatigue, and it feels awesome." (P2)

"I have found that as my time on this study has progressed that my energy levels have increased and that I have been more alert and lively in the workplace and particularly at evenings and weekends whereby I can now go on walks with the family." (P6)

#### Psychological improvements

Some participants discussed how taking part in the HIIT sessions improved their ability to cope, and accomplishing something they didn't believe they could do provided a sense of achievement.

"I feel much better and able to cope with everything." (P11)

"It was enlightening. I didn't think I'd be able to do that." (P1)

"Really good, really positive. I come out afterwards and go oh guess what I did."  
(P2)

"I actually felt quite euphoric and quite keyed up afterwards." (P4)

### *Theme 3: Negative impact of the HIIT intervention*

The negative effects focused on the participant's experiences during the intervention.

Negative experiences can be broken down into impact on symptoms, the dose of exercise, and the mode of exercise.

#### Negative impact on symptoms

Despite some participants reporting positive impact on fatigue and energy levels participants did experience some exacerbation of symptoms. Participants discussed feeling nauseous during sessions and feeling wiped out.

"I sometimes felt sick. A couple of times I went deaf. That was the only thing that worried me really because that is a symptom I get. One of the times it lasted all day." (P1)

"I had some muscle aching but also generally wiped out." (P11)

#### The dose of exercise

Participant felt that as the sessions progressed, they became too long. By the end of the intervention, participants were completing ten HIIT repetitions. One participant felt that eight intervals were the ideal number, but ten was too much.

"It started to get quite tedious. My optimum number was 8 [intervals]. 8 felt like a challenge and 10 felt hideous. I left feeling slightly deflated that it had been so hideous." (P4)

The mode of exercise

Some participants would have preferred other modes of exercise than the exercise bike.

Participants discussed how uncomfortable the bike was, and this may have impacted their enjoyment of the sessions.

"I do wish bikes were more comfy. I literally had a sore bum for the first couple of weeks." (P2)

"The bike was horrible. I hated the bike." (P9)

### ***Retention***

One person dropped out of the study due to time constraints and distance to travel. The participant completed baseline measures and one week of exercise sessions (n= 2 sessions). The participants exercise session data was not included in the analysis. The remaining 10 participants completed all phases of the study.

### ***Attendance at exercise sessions and compliance with the training protocol***

Through the 6-week intervention, there was a maximum of 12 sessions available for each participant, totalling 132 sessions for the study sample. Participants attended 115 sessions (87%). For the HIIT sessions, there was a mean attendance of 10.5( $\pm 3$ ) sessions. Reasons for not attending exercise sessions included: illness, work commitments, and injury. One person dropped out of the study after attending two exercise sessions. Participants were encouraged to reach 85-95% of HRmax during each interval. Of the 115 attended sessions, 106 sessions (92%) achieved an 85-95% average heart rate max for the intervals. The mean RPE for the intervals was 16.5 ( $\pm 1.2$ ). Which

corresponds to hard/very hard on the RPE scale.

### ***Safety***

There were 27 events recorded during the study. All events were non-serious. A participant suffered glute and lower back pain while on the bike, which resulted in the termination of the immediate exercise session and missing two further sessions. Eight participants experienced exacerbation of symptoms during exercise sessions. Table 4 shows the category of adverse event and the number of sessions it occurred. The exacerbated symptoms were all previously experienced by the participants; no new symptoms were discovered. All exacerbated symptoms returned to normal shortly after the exercise sessions.

### ***Outcome measures***

Outcome scores for all outcome measures are shown in table 5. These include data for 10 participants who completed the intervention. As the study was not designed to measure intervention effects, only descriptive statistics are presented.

Mean changes for all outcome showed positive improvements, although some individual components of quality of life saw decreases overall quality of life, mental health, and physical health showed positive mean change.

### **Discussion**

Despite the well-documented benefits of physical activity, only 20% of pwMS engage in recommended amounts (Motl et al. 2017). HIIT is widely described as a promising approach to exercise prescription for public health (Decker and Ekkekakis 2017). It has been suggested that HIIT should play a central role in health activity guidelines to maximise the benefits of physical activity globally (Wisløff et al. 2015).

This study aimed to examine if a HIIT intervention is acceptable and feasible for people with low MS-related disability by exploring participant experiences, intervention safety, and to estimate any effects.

Participants reported some apprehension and fear before taking part in the study, mostly related to their perceived ability to undertake the exercise prescription. Fear and anxiety are the most common barrier to exercise reported in pwMS (Learmonth and Motl 2015). Apprehension was reinforced in some participants by friends and family who stressed concern for the participant's health. This underlines the critical role that family can play in facilitating or inhibiting pwMS from exercising (Kalb et al. 2020).

Despite their apprehension, the participants still consented to participate in the study. One key reason for participating was because their consultant recommended the study. Health professionals are trusted by patients and are viewed as credible messengers of exercise (Richardson et al. 2019), which has been consistently shown to shape a patient's behavioural intention (Orrow et al. 2012).

As the intervention progressed, participants discussed strong feelings of achievement after completing the sessions. Proving to themselves that they could complete the exercise sessions, had a positive effect on their confidence. This suggests a positive increase in exercise self-efficacy, although this was not investigated in this study. Research has documented the linear relationship between self-efficacy and objective physical activity in pwMS (Casey et al. 2018). Self-efficacy is central construct of the Social-Cognitive Theory (SCT) (Bandura 1997), which is the most applied theory to increase physical activity behaviour (Uszynski et al. 2018). Drawing from constructs of the SCT (behavioural capability, observational learning, expectations, self-efficacy) (Bandura 1997), the HIIT intervention appeared to improve the participants' beliefs in their capabilities and the consequences of the behaviour



(expectations). When a person has successfully completed a task, they develop knowledge of one's ability to complete similar tasks in the future (Warner et al. 2014). Participant's condition-related symptoms (e.g. fatigue) or perceived barriers (fear of exacerbation of symptoms) can affect their perceived capabilities and expectations of exercise behaviour reducing self-efficacy (Casey et al. 2018). Data here suggests building SCT constructs (behavioural capability, observational learning, expectations, self-efficacy) into the design of HIIT exercise interventions for pwMS might help engage and sustain their participation. However, this would need to be explicitly explored in future research.

Pre-intervention apprehension reported by participants was not unfounded. Six out of the ten participants reported feeling nauseous, exhausted, or uncomfortable during a session, none of which resulted in the termination of the session. In healthy populations, HIIT has been shown to cause feelings of exhaustion and severe fatigue lasting 10-to-20 minutes (Coyle 2005). Eight participants reported incidents of mild symptom exacerbation during the sessions. This included tingling in extremities, fatigue, blurred vision, partial deafness, and weakness down one side. These exacerbations highlight the immediate effects exercise can have on MS symptoms. Exercise is beneficial and vital for pwMS, but it should not cause overheating symptoms (Halachi et al. 2017).

The present study reported one injury, a muscle strain, during an exercise session. The participant rested and was able to continue the study. Previous HIIT studies in pwMS have shown a low amount of adverse events. According to Campbell and colleagues (Campbell et al. 2018), only one of the seven studies in their review reported any adverse events (Collett et al. 2010). Collett and colleagues (2010) reported that seven participants experienced adverse events in the high-intensity groups compared to

none in the lower intensity continuous exercise group. None of the studies included in the review by Campbell and colleagues (Campbell et al. 2018) defined what an adverse event is. This makes it difficult to compare the number of events with the present study. Additionally, Collett and colleagues (Collett et al. 2010) as with the present study, were specifically exploring safe, effective exercise intensity. In future studies, it is vital to ensure the participants understand the immediate effects of exercise (Learmonth and Motl 2015). Symptom exacerbation should also be defined and documented throughout any research study (Learmonth and Motl 2015).

The attendance at the exercise sessions was high (87%). This is similar to previous research in other conditions, such as cardiometabolic disease (82-85%) (Weston et al. 2014) and type 2 diabetes (90%) (Jelleyman et al. 2015). Previous research in high-intensity exercise for pwMS has shown higher attendance levels (93%) (Langeskov-Christensen et al. 2020)

Participants were also able to complete the high-intensity protocol, with 92% of sessions meeting the required heart rate. This suggests participants were undeterred by the symptom exacerbation they experienced during the intervention. Additionally, the several participants discussed having positive feelings after completing the sessions. Overall, six-weeks of HIIT in pwMS was shown to improve exercise capacity in the participants. This is consistent with other conditions such as diabetes, stable angina, heart failure (Shiraev and Barclay 2012). Participants also showed improvements in physical health, mental health, and overall quality of life, which supports the findings in previous research (Zaenker et al. 2017). Although as previously stated the study was not designed to measure intervention effects.

Participants discussed positive and negative experiences of participating in the intervention, highlighting the potent nature of HIIT (Coyle 2005). Participants reported

improvements in perceptions of fatigue, which were consistent with previous research (Crank et al. 2017). Some participants discussed how the intervention had changed their energy levels, resulting in them being able to exercise more, socialise, and spend time with family, which previously had been restricted. Participants did, however, discuss how uncomfortable they felt during sessions and how tedious the sessions became towards the end of the intervention. Despite the positive experiences, the negative perspectives suggest at times, the sessions were not pleasant or enjoyable. Enjoyment is a crucial predictor of long-term exercise adherence (Hardcastle et al. 2017). Research investigating the effect and enjoyment of HIIT found that HIIT was rated as less pleasant and less enjoyable than moderate-intensity exercise (Decker and Ekkekakis 2017). These results question the long-term appeal and sustainability of HIIT.

The present study was conducted in a laboratory setting with supervision and encouragement from an experienced research team. The likelihood of a participant independently completing HIIT at the correct intensity is low, especially if the sessions are not enjoyable (Hardcastle et al. 2017). These results question the long term appeal of HIIT (Biddle and Batterham 2015). HIIT could be used as a short-term option to boost an individual's fitness levels, but alterations are needed to make it more appealing long term.

### **Limitations**

This study aimed to determine the potential acceptability and feasibility of HIIT for pwMS. Findings should be considered in light of the small sample size, lack of a comparison group, and the short length of the intervention. It is possible that participants recruited for this study were more motivated to engage in exercise than people from the general MS population. Additionally, only people with low MS-related disability were recruited for this study, and within this group, there was heterogeneity in

physical fitness, physical activity levels and body weight. The study team also did not collect data on the type of MS with which participants were diagnosed. Different MS types will likely tolerate exercise differently. Nevertheless, providing a voice for the perspectives and experiences of high-intensity interval training with pwMS is a valuable tool to evaluate the feasibility of an intervention.

## **Conclusion**

To our knowledge, this is the first study to use participant perspectives to investigate the acceptability and feasibility of a HIIT intervention in pwMS. The HIIT intervention was well attended, safe, and showed a positive trend towards increasing cardiorespiratory fitness. Participants expressed the challenge of completing the high-intensity exercise resulted in feelings of achievement, improved confidence and reduced perceived fatigue. Participants expressed pre-intervention fear and apprehension, and there were examples of worsening of symptoms during the sessions. It is recommended that in future research, pwMS are made aware of the potential temporary effects of acute bouts of exercise. Participants found the sessions tedious and felt uncomfortable during sessions, and so whilst this study suggests that HIIT is a safe form of exercise for pwMS, questions remain regarding the appeal in pwMS.

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