

1 Energy Matching of a High Intensity Exercise Protocol with a Low  
2 Intensity Exercise Protocol in Young People  
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## 20 Abbreviations:

21 EE – energy expenditure

22 HIIE- high intensity interval exercise

23 HR – heart rate

24 LIE – low intensity exercise

25 METs – metabolic equivalents

26 READY - randomised controlled trial of energetic activity for depression in young people

27 RPE – ratings of perceived exertion

28 VCO<sub>2</sub> – volume of carbon dioxide

29 VO<sub>2</sub> – volume of oxygen

30

## 31 1. Introduction

32 Recent research suggests that exercise is a beneficial adjunct therapy for many health conditions [1]. For  
33 clinicians to be able to prescribe exercise to patients, more information is required around the intensity and  
34 duration of exercise and more specifically, guidelines need to be developed to ensure a consistent approach to  
35 patient care. When designing exercise intervention trials to explore the effects of different intensities, the same  
36 volume of exercise needs to be employed between experimental groups to ensure that any differences in responses  
37 result from differences in intensity and not energy expenditure (EE). This is because metabolic and peripheral  
38 adaptations such as mitochondrial and capillary density respond to the volume of exercise training rather than the  
39 intensity [2].

40

41 The current study was undertaken as pilot work for a randomised controlled trial of energetic activity for  
42 depression in young people (13-17 years) (the READY trial:  
43 <https://www.journalslibrary.nihr.ac.uk/programmes/hta/177810/#/>). Prior to undertaking the READY trial, the  
44 protocol for the exercise intervention was pilot tested. To ensure fair comparison between the high and low  
45 intensity group exercise protocols they needed to be energy matched. The high intensity exercise protocol was  
46 adapted from Taylor et al. [3] which included activities such as boxing and football drills. These had been  
47 previously demonstrated to be acceptable, enjoyable and engaging amongst young people (14.0 ±0.3 years). The  
48 duration of the high intensity exercise intervention previously utilised by Taylor et al. [3] was 9 minutes, which  
49 was achievable by the participants and therefore the present pilot tested used this duration for one of the activities;  
50 boxing. The low intensity exercise intervention selected for the study was indoor walking football. At the time of  
51 writing this there was no research measuring exercise intensity or EE in indoor walking football in young people.  
52 However, as walking at comfortable speeds is categorised as low intensity [4], the research team chose it as an  
53 appropriate activity. Walking per se would have brought an extraneous variable as it would have had to be  
54 completed outside and hence may affect depressive symptoms differently to indoor exercise. Nevertheless, for  
55 the purpose of this pilot testing, simulated walking football was compared with walking to ensure there were no  
56 substantial differences in intensity.

57

58 The pilot testing aimed to match the EE in the low and high intensity exercise interventions using indirect  
59 calorimetry. This involved calculating the average EE per minute during the low intensity protocol and  
60 determining the exercise duration to match the EE during the 9-minute-high intensity protocol.

61

## 62 2. Methods

63 Twenty-four participants (15 boys) volunteered to take part in this study (see Table 1 for characteristics).  
64 They completed a health screen questionnaire prior to participating and were found to be healthy and injury free.  
65 They received a £10 Amazon voucher for taking part. Recruitment occurred via advertisement at the University

66 of Hertfordshire which targeted at staff with adolescent children. Ethical approval was obtained from the  
67 University of Hertfordshire ethics committee (Reference number: LMS/SF/UH/03759) and the study followed the  
68 principles outlined in the Declaration of Helsinki. Informed consent was obtained from both the parent and the  
69 adolescent, and participants were free to withdraw at any point prior to the completion of data collection.

70  
71 \*\*\*Table 1 near here\*\*\*

72  
73 The participants attended the sports science laboratory in sports clothing on one occasion after fasting for at  
74 least 2 hours. The session lasted approximately one hour where they first undertook walking on a treadmill at a  
75 comfortable walking speed for 5 minutes to represent low intensity exercise. Following this, they completed the  
76 low intensity exercise (LIE) protocol, simulated walking football, for 10 minutes, and then rested until their heart  
77 rate (HR) had returned to baseline. Finally, they completed the high intensity interval exercise (HIIE) protocol,  
78 which was boxing using focus pads lasting 9 minutes.

## 80 2.1 Protocol:

81 On arrival to the laboratory, stature (m) was measured on a stadiometer (Seca 217 Stadiometer, Seca,  
82 Hamburg, Germany) after holding a maximal inhalation, with participants standing without shoes, heels and back  
83 touching the stadiometer, head in the Frankfurt horizontal plane. Body mass (kg) (Seca 799, Seca, UK) was  
84 measured on a flat, uncarpeted surface. Following this, the participant was shown how to use the treadmill  
85 (H/P/COSMOS Sports & Medical, Nussdorf-Traunstein: Germany) correctly, ensuring they were able to  
86 comfortably walk on it. A comfortable walking speed was determined for each participant depending on their  
87 height (<165cm they walked at 4 km.hr<sup>-1</sup>, >165cm they walked at 4.5 km.hr<sup>-1</sup>).

88  
89 A HR monitor strap (Polar H10, Polar Electro Oy, Finland) was positioned around the participant's chest  
90 and baseline HR was recorded after 5 minutes of seated rest. The participant then had a facemask (V Mask, Hans  
91 Rudolph, USA) placed over their nose and mouth and secured in place with a hairnet (Hans Rudolph, USA). The  
92 portable gas analyser (Metamax 3B, Cortex Biophysik, Leipzig, Germany) was positioned like a rucksack over  
93 their shoulders. The weight of the gas analyser was ~1.3 kg. The participant was asked to walk for 5 minutes at a  
94 comfortable walking speed on the treadmill. During the last minute of walking, the participant provided a rating  
95 of perceived exertion (RPE; 6-20 scale) for how hard they found the intensity of exercise. On completion, they  
96 were asked to undertake the simulated walking football task. This took place outside of the laboratory. They  
97 walked between 2 cones placed 14m apart. Every 4<sup>th</sup> repetition they dribbled the football and then kicked it at 70-  
98 degree angle at the end of the 14m. They continued walking between cones. This was repeated until 10 minutes  
99 was completed. During the last minute of the simulated walking football RPE was recorded. Participants then sat  
100 approximately for 5 minutes until their breathing and HR had returned to resting levels.

101  
102 They completed the HIIE protocol. This included 45s of high intensity boxing exercise followed by 90s of  
103 rest. This was repeated four times (to provide a total duration of nine minutes); see Table 2 for exercise details.  
104 The facemask and gas analyser were worn throughout the whole protocol and an RPE rating was given  
105 immediately post the last high intensity effort.

106  
107 \*\*\*Table 2 near here\*\*\*

## 109 2.2 Gas Analysis:

110  
111 Prior to data collection, the gas analyser was calibrated using a three-point calibration procedure as per  
112 manufacturer's instructions. First, barometric pressure was analysed followed by calibration of the analyser  
113 against a mixture of gases with known concentrations (5% CO<sub>2</sub>, 17% O<sub>2</sub>). Finally, the volume transducer in the  
114 analyser was calibrated with a 3-litre calibration syringe (Series 5530, Hans Rudolph, USA).

115  
116 Variables recorded breath by breath from the gas analyser during exercise included oxygen consumption  
117 ( $\dot{V}O_2$ ; l.min<sup>-1</sup>), carbon dioxide production ( $\dot{V}CO_2$ ; l.min<sup>-1</sup>) and HR (bpm) every breath. Consequently, indirect

118 calorimetry was used to calculate EE (kcal.min<sup>-1</sup>) using stoichiometric equations specifically developed for  
119 exercise at intensities between 40-50%  $\dot{V}O_{2peak}$  (low intensity) and 50-75%  $\dot{V}O_{2peak}$  (moderate to high intensity)  
120 as shown below [5].

121  
122 Equation 1:

123 Energy Expenditure for low intensity exercise (kcal.min<sup>-1</sup>) = [(0.575 · VC02) – (4.435 · V02)]

124  
125 Equation 2:

126 Energy Expenditure for high intensity exercise (kcal.min<sup>-1</sup>) = [(0.550 · VC02) – (4.471 · V02)]

127  
128  
129 2.3 Data analysis:

130  
131 Total EE was calculated from the expired gases of the HIIE protocol using Equation 1 above for high  
132 intensity exercise intervals and Equation 2 for the rest intervals. Then an average EE for one minute for the LIE  
133 was calculated using Equation 2. From this, the duration needed for the LIE to match the HIE was calculated  
134 using Equation 3.

135  
136 Equation 3:

137 Total duration in minutes to energy match = Total HIIE EE / LIE average EE per minute

138  
139 To determine the Metabolic equivalents (METs) of the exercise, the estimated number of calories was  
140 calculated for one hour and then divided by the participant's weight in kg. This was then divided by the estimated  
141 resting metabolic rate of either adolescent males (1.28 kcal/kg x h) or females (1.11 kcal/kg x h). This was adapted  
142 from Melzer et al. [4]. Microsoft Excel was used to determine means and SD.

### 143 144 3. Results

145  
146 The mean ±SD calculated time for LIE to energy match the HIIE protocol for all participants was 11.9 ±1.9  
147 min. As can be seen in Table 3, exercise intensity was similar between treadmill walking (54 ±8% HR<sub>max</sub>) and  
148 LIE (59 ±8% HR<sub>max</sub>) whereas HIIE produced a higher HR of 82 ±7%HR<sub>max</sub>. Table 3 also displays the RPE scores  
149 for each exercise protocol, demonstrating treadmill walking to be 8 ± 2 (between extremely light and very light),  
150 LIE was 9 ± 2 (very light) and HIIE was 16 ± 2 (between hard and very hard). Total EEs for the duration of each  
151 exercise protocol (treadmill 5 minutes, LIE 10 minutes and HIIE 9 minutes) are presented in Table 3, along with  
152 the average EE per minute and as METS.

153  
154 \*\*\*Table 3 near here\*\*\*

### 155 156 4. Discussion

157 This pilot testing was undertaken to determine the duration of low intensity exercise, in this case walking  
158 football, needed to energy match a high intensity exercise protocol such as boxing in young people. Findings  
159 suggest that, approximately 12 minutes of LIE is needed for 9 minutes of HIIE. It must be noted that the HIIE is  
160 equivalent to 3 minutes of actual exercise along with 6 minutes of rest whereas the LIE is continuous exercise for  
161 12 minutes. When designing exercise interventions using similar intensities (~80%HR<sub>max</sub> for HIIE and  
162 ~55%HR<sub>max</sub> for LIE), the LIE duration therefore needs to be 133% that of the total HIIE protocol duration.

163  
164 When calculating METs for this study, the LIE protocol was 3.6 METs and the HIIE was 5.4 METs which  
165 classifies them as both moderate physical activities. However, the HR as a percentage of maximum shows distinct  
166 differences between the exercise protocols. High intensity interval training is thought to be ≥80% HR<sub>max</sub> [2] and  
167 the present study demonstrated a HR<sub>max</sub> of 82 ±7%. In addition, the participants perceived the LIE to be 'very

168 light' whereas they rated the HIIE between 'hard' and 'very hard', emphasising the differences in intensity  
169 between protocols. It is important that when implementing a HIIE protocol similar to the current study,  
170 participants need to be constantly motivated to exercise as hard as they can to ensure they are exercising at a  
171 sufficiently high intensity.

172

173 The treadmill protocol was included in this study to represent low intensity exercise by walking at a  
174 comfortable speed and comparing it to the simulated walking football protocol (LIE). The %HR<sub>max</sub> between  
175 conditions were similar with the treadmill walking eliciting  $54 \pm 8\%$  and the LIE  $59 \pm 8\%$ . As both are lower than  
176  $60\%$  HR<sub>max</sub>, they can be classified as low intensity exercise. Physiological variables were similar between the  
177 treadmill walking and the LIE, as well as the perceived exertion being between extremely light and very light  
178 suggesting that the LIE protocol represents a true low intensity exercise.

179

180 Exercise interventions for young people with depression are poorly defined, making it difficult for multi-  
181 disciplinary professionals to prescribe them. In preparation for a randomised controlled feasibility trial, this study  
182 has identified the level of LIE that would map on to HIIE to provide evidence on their respective impact on young  
183 people with clinically significant depressive symptoms. There is limited research comparing energy expenditure  
184 in this age group for high and low intensity exercise, therefore the current study adds to the potential methodology  
185 for energy matching exercise trials in adolescents. Nevertheless, there are some limitations to consider. Firstly,  
186 participants provided their own perception of maximal exercise when performing the HIIE intervention and this  
187 can vary for any given intensity. Secondly, whilst the present study has tested two types of exercises, there are  
188 others of a similar nature that could form the basis of a full-scale trial and will be developed with input from young  
189 people themselves. In this study, participants were not familiar with wearing the gas analysis equipment and this  
190 may have elevated the respiratory values slightly when performing the exercise. Though EE is an indirect  
191 estimation and a whole room calorimeter would be required to do a direct measure, gas analysis is an accepted  
192 and more practical measure. Withstanding these considerations, our data provide a basis for designing the exercise  
193 interventions for a future trial that will address the effectiveness of different intensities for managing depression  
194 in young people.

195

## 196 5. Conclusions

197

198 In conclusion, to ensure the authors are comparing the effect of high intensity and low intensity exercise on  
199 depression in adolescents in the future READY trial the exercise duration for the LIE needs to be 133% of the  
200 HIIE. This is important when designing the training load for the training programme. In doing so, the current  
201 study highlights potential methodologies for researchers wanting to energy match exercise interventions for future  
202 clinical trials.

203

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207

## 208 Declarations

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210 methodology, L.B., N.H., A.C. and A.J.; investigation, L.B.; resources, L.B., N.H., A.C., A.J., J.J., S.W., S.M.,  
211 S.S., K.I., D.T. and DT2.; data curation, L.B.; writing – original draft preparation, L.B.; writing – review and  
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219 **Code availability:** Not applicable

220 **Ethics approval:** Obtained from the University of Hertfordshire ethics committee (Reference number:  
221 LMS/SF/UH/03759).

222 **Consent to participate:** Informed consent was obtained from both the parent and the adolescent.

223 **Consent for publication:** All authors consent.

224 **Availability of data and material:** Available on request to corresponding author.

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