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Short-Term High-Intensity Rowing Ergometry Training Improves Rowing Performance Equally in Healthy Weight and Obese Adolescents

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ABSTRACT

Purpose: Childhood obesity is a major health concern and physical activity is commonly proposed as an intervention strategy to combat the increasing prevalence of overweight and obesity in young people. The aim of this study was to examine the effect of high-intensity, supervised, rowing ergometer training on maximal and submaximal rowing performance in healthy weight and centrally obese adolescents (12–13 y). **Methods:** Participants were randomised to either 6-weeks of supervised rowing ergometry, comprising of 2 sessions per week with each session comprising of 2x3-minute bouts of high intensity rowing ergometry (n=57), or a control group who continued with their habitual activities (n=45). At baseline and follow-up, rowing performance was assessed via a submaximal test and a 3-minute maximal test. **Results:** Six-weeks of rowing ergometer training significantly improved maximal exercise performance; total distance rowed in a 3-minute maximal effort improved by 19.7m (2.7%) (time*group, *p=0.018*) and produced a significant reduction in perceived effort in response to a set submaximal load (60W) (time* group, *p=0.040*). At baseline total distance rowed during the 3-minute maximal test was significantly affected by body mass (main effect of body mass, *p=0.002*), whereby a higher body mass was associated with enhanced rowing performance. However, the pattern of change over time was not different between healthy weight and centrally obese adolescents (time*group*waist centile, *p=0.577*). **Conclusions:** A 6-week high intensity rowing ergometry training intervention improved maximal rowing performance. This improvement was similar in healthy weight vs. overweight and obese adolescents; yet overall overweight and obese adolescents had superior rowing performance compared to their healthy weight counterparts, suggesting that rowing may be an attractive exercise modality for interventions in overweight and obese young people.

Key Words:_ADOLESCENCE, OBESITY, PHYSICAL FITNESS, ROWING ERGOMETRY, MAXIMAL EXERCISE, SUBMAXIMAL EXERCISE

INTRODUCTION

The most recent statistics for childhood obesity in the UK reported in the National Child Measurement Programme demonstrate that in England in 2021/22, 23.4% of year 6 children (aged 10-11 years) were obese and 14.3% were overweight[1]. Childhood obesity is a major health concern and one of the most serious challenges in modern healthcare[2]. Specifically, an elevated body mass index (BMI; kg/m^2) in young people is associated with an increase in risk for an array of health outcomes and metabolic disorders, which include raised fasting glucose, impaired glucose tolerance, type 2 diabetes mellitus, and metabolic syndrome[3]. A recent (2019) systematic review revealed that obese young people were 4.4 times more likely to have high blood pressure and 1.4 times more likely to have prediabetes compared to healthy weight young people[4]. Further to this, obese young people also have an increased risk of adverse mental health outcomes[3]. Large cohort studies also demonstrate an association between childhood obesity and a marked increase in risk for cardiovascular disease in adulthood[5]. Thus, early interventions to reduce childhood obesity and encourage healthy lifestyle behaviours in young people are vital to prevent this pathway to adulthood cardiovascular disease[5] and to reduce obesity-associated complications during childhood and adolescence.

One of the key healthy lifestyle behaviours that should be encouraged in young people is engagement in physical activity[6]. A report from the Chief Medical Officers in the UK states that young people should be taking part in moderate or vigorous intensity sport and physical activity for a minimum of 60-minutes every day to improve their health[6]. However, physical activity statistics from 2022 report that only 44.6% of young people aged 5-16 in England met the Chief Medical Officers' guidelines[7].

Physical activity interventions are commonly prescribed for obese young people, given that physical activity promotes healthy physical development[8], alongside the maintenance of healthy weight and enhanced cardiovascular health[9]. However, the long-term adherence to such physical activity interventions is limited, as represented by the increasing prevalence of overweight and obesity in young people in England[1] and the low rates of participation in moderate-to-vigorous daily physical activity[7]. Therefore, the design and implementation of future interventions should consider the ecological validity of the physical activity mode and the setting in which the intervention is delivered, ensuring that the intervention is tailored towards the specialist needs of young people with overweight and obesity.

Schools are an attractive setting for physical activity interventions given their potential to deliver an array of supervised physical activity opportunities that reach virtually all young people[10]. However, even though habitual activity patterns in young people are typically high-intensity and intermittent in nature[11], high intensity training is not commonly delivered in a school setting. High intensity training offers a time efficient training strategy that has been demonstrated to offer an array of health benefits, including improved body composition in obese young people[12–14]. Whilst not common in school curricula, high intensity training interventions have been successfully applied in schools in healthy weight[15,16] and overweight/obese young people[16,17]; and can be successfully integrated into physical education (PE) lessons[18,19]. Furthermore, the time-efficiency of high-intensity training interventions may increase their appeal within schools as reduced time for equal or superior benefits enable less disruption to academic learning time.

It is well documented that young people who are overweight or obese are less likely to engage in regular physical activity[20]; and are usually less physically active than their non-obese counterparts[21], which is partly due to lower perceived competence for physical activity in this population, particularly in weight-bearing activities[22–25]. Motivational theories emphasise the importance of increasing actual and perceived competence among overweight and obese young people to encourage adherence to physical activity[26–28]. Indeed, evidence from cross-sectional data suggests that obese young people, when compared to their healthy weight counterparts, have reduced physical competence (development of movement skills and patterns, and the capacity to experience a variety of movement intensities and durations) and perform poorly during weight-bearing activities[29–31]. Rowing ergometer exercise is a potentially attractive target for overweight/ obese young people as body mass has been previously demonstrated to have a positive contribution to rowing ergometer performance[32]. Importantly however this relationship was demonstrated in elite male junior athletes (considered the best 49 junior rowers in the country), and the relationship between body mass and rowing performance in overweight/obese young people remains unknown[32]. Thus, whilst there is the potential for improved physical competencies for overweight and obese young people with rowing exercise, the utility of rowing ergometer exercise as an intervention target in overweight and obese young people has not been examined and as such the effect on performance and health has not been determined.

Therefore, the aim of the present study was to examine the effects of high intensity, supervised, structured rowing ergometer training twice weekly over a 6-week period on submaximal and maximal rowing performance in healthy weight, and centrally obese, adolescents.

METHODS

Overview

The study was approved by the institution's ethical committee. Forty-four secondary schools in Birmingham, England, who had access to rowing ergometers, were contacted via letter and invited to participate. Invited schools were provided with material explaining the purpose of the research and detailed descriptions of the procedures involved. Seven schools agreed to participate in the study. Adolescents (aged 12 and 13 years) were randomised to either an intervention group (6-weeks of twice weekly researcher-supervised rowing ergometer training during their school PE lessons), or a control group who continued with their habitual activities. Participants completed a range of assessments (described below) at baseline and post- training.

Participants

Participant were eligible if they were males or females aged 12-13 years and were pupils at one of the participating schools. All participants and their parents/guardians were fully informed of the requirements of the study and gave written assent (participants) and informed consent (parents/guardians). Parents/guardians also completed a health screen questionnaire on behalf of their child to ensure there were no health conditions that could be adversely affected by participating in the study. In all but one of the schools (where a single class participated) pupils were randomly assigned to a control or training group, either by class (3 schools, using block randomisation) or on an individual basis (3 schools, using a table of random numbers). In total, 166 pupils from 7 secondary schools were enrolled into and began the study. During the study 64 participants withdrew/dropped out (n =39 in the training group and n =25 in the control group), resulting in 102 participants completing the study (n = 57 in the training group, n = 45 in the control group).

Anthropometric measures

At baseline, stature and body mass were measured using a portable stadiometer (Seca Leicester, Cranlea, Birmingham, U.K.) and digital scales (SECA Electronic Scale 888, Cranlea, Birmingham, U.K.), respectively. The body mass and stature of the participant were used to calculate BMI (body mass [kg]/ stature $[m]^2$).

Exercise Testing

All participants performed a submaximal exercise test (on a Model C or D Concept2 rowing ergometer, Concept2 Ltd., Nottingham, U.K.) consisting of 3 x 3-minute stages, separated by 90-seconds of rest, at intensities equivalent to a power output of 60, 71, and 86 Watts (W). Heart rate (HR) and rate of perceived exertion (RPE) were recorded immediately following the completion of each exercise stage[33].

All participants then performed a maximal test consisting of one 3-minute maximal effort. The outcome measure was total distance rowed (meters [m]). The drag factor (resistance)[35] of all rowing ergometers was set at 105 prior to each testing session, for both the submaximal and maximal rowing tests.

Exercise Training

Participants randomised to the exercise training completed 2 x 3-minute bouts of high intensity rowing ergometer exercise, twice weekly during the schools' PE lessons across the six-week training intervention. In total, participants completed 4 x 3-minute bouts per week in total for six-weeks, which equated to 72-minutes of rowing ergometry in total across the intervention period. The drag factor (resistance)[34] of all rowing ergometers was set at 105 prior to each training session. Participants were asked to perform a maximal effort for each 3-minute training bout.

Participants recruited to the resting control group maintained their habitual physical activity for the six-week period.

Body Composition

Waist and hip circumferences were measured using a tape measure to the nearest 1 mm (Gaiam, HAB International Ltd., Warwickshire, U.K.). Participants were also categorised by their waist centile (below 90 [not centrally obese], and 90 and above [centrally obese])[35].

Resting blood samples

Participants provided a rested and fasted fingertip (capillary) whole blood sample. This fingertip capillary blood sample was immediately analysed for high sensitivity C-reactive protein (hs-CRP), alanine aminotransferase (ALT), aspartate aminotransferase (AST), total cholesterol, high-density lipoprotein (HDL)-cholesterol, (low-density lipoprotein [LDL]-cholesterol was estimated [total cholesterol minus HDL-cholesterol]), triacylglycerol (TAG) and blood glucose, using an automated analyser and commercially available cassettes (Cholestech LDX, Point of Care Services Limited, U.K.).

Statistical analysis

All statistical analyses were performed using SPSS software (version 28, Chicago, Illinois, U.S.A.). The age, stature, body mass, waist circumference, and BMI (body mass [kg] / stature [m^2]) of the control and training groups prior to the 6-week intervention were analysed using a t-test for independent samples.

The distance rowed in a 3-minute maximal effort was analysed using a three-way (group * time* sex) Analysis of covariance (ANCOVA) with repeated measures for time. Body mass pre-intervention was used as a covariate, as rowing is a 'weight supported' activity, and therefore body mass is likely to influence the distance rowed during a maximal effort[37]. The distance completed by the training and control groups prior to the intervention period was analysed using a one-way ANCOVA, with group as the independent variable and body mass as a covariate.

The blood metabolite responses of participants in terms of hs-CRP, ALT, AST, total cholesterol, HDL, LDL, TAG, and blood glucose were analysed via a three-way (time* group * sex) ANOVA, with repeated measures for time. Data are presented as mean and standard deviation (SD) or 95% confidence interval (95% CI) for change values, and statistical significance was accepted as $p<0.05$.

RESULTS

Participant characteristics

One-hundred and sixty-six participants were initially enrolled and completed the baseline visit. One-hundred and two participants completed the intervention, 57 in the training group (males n = 25; females n = 32) and 45 in the control group (males n = 12; females n = 33). There was no difference in the age, body mass, BMI, waist circumference, or waist circumference centile between those who dropped out and those who adhered to the programme (all $p > 0.05$). Specifically with regards adiposity, BMI of those who dropped out was 20.42 ± 3.54 kg/m^2 compared to 20.86 ± 3.65 kg/m^2 in those who adhered to the programme ($p = 0.457$).

Participant characteristics for those who completed the intervention at baseline, follow-up, and the change over time, are presented in Table 1. There were no statistically significant differences in participant characteristics between the training and control group at baseline (all $p > 0.05$).

Training effects: submaximal performance-Heart rate

Heart rate following the 60, 71, and 86 W bouts of rowing was not statistically significantly different between the training and control groups (main effect of group: 60 W, $p = 0.279$; 71 W, $p = 0.566$; 86 W, $p = 0.683$). Furthermore, the pattern of change in heart rate following each stage of the submaximal test from pre- to post-intervention was similar between the training and control groups (time* group: 60W, $p = 0.886$; 71W, $p = 0.465$; 86W, $p = 0.512$) (Table 2 & Figure 1). Body mass had no effect on heart rate after submaximal exercise (main effect of body mass: 60W, $p = 0.891$; 71W, $p = 0.827$; 86W, $p = 0.506$).

Training effects: submaximal performance-RPE

RPE post 60W pace was not statistically significantly different between training and control groups (main effect of group, $p = 0.790$). However, RPE post 60W pace was reduced following training whilst it remained similar in the control group (exercise: -1.0 [-1.8, -0.2]; control -0.1 [-0.9, 0.8]; time* group: $F_{(1,86)} = 4.40$; $p = 0.040$; Table 2 & Figure 1). RPE post 71W pace did not statistically differ between training and control groups (main effect of group, $p = 0.300$) nor was RPE post 71W pace reduced following training (time* group, $p = 0.110$). RPE post 86W pace did differ between training and control groups, but there was a tendency (main effect of group, $p = 0.053$) for RPE post 86W pace to be lower in the training group (estimated marginal mean ± standard deviation; control: 14.42 ± 2.03; training: 13.31 ± 2.04). However, the pattern of change over time was statistically similar between the training and control groups (time *group, $p = 0.270$). Body mass had no effect on RPE after submaximal exercise (main effect of body mass: 60W, $p = 0.284$; 71W, $p = 0.121$; 86W, $p = 0.132$).

Training Effects: Maximal performance

Maximal rowing distance in a 3-minute maximal effort was not statistically significantly different between groups (main effect of group, $p = 0.072$). However, six-weeks of rowing ergometer training statistically significantly improved the distance rowed in the training group when compared with the control group (exercise: 19.7 [3.9, 35.6] m; control -9.5 [-20.8,1.8] m; time* group $F_{(1,97)} = 5.83$; $p = 0.018$; Table 2 and Figure 2). Sex did not have a statistically significant effect on the distance rowed (main effect of sex, $p = 0.409$), nor did sex influence the effect of training (time *group *sex, $p = 0.216$).

Total distance rowed during the 3-minute maximal test was statistically significantly affected by body mass (main effect of body mass, $F_{(1,97)} = 9.90$; $p = 0.002$). Parameter estimates indicated that for each kg increase in body mass above the average body mass for the group, the distance rowed increased by 1.3 m pre-, and 1.9 m post- 6-weeks of training. However, body mass did not influence the training effect (time *group *body mass interaction, $p = 0.348$).

When sub-grouped according to waist circumference centile (centrally obese = above 90th centile; non-centrally obese = below 90th centile) there was a statistically significant effect of waist centile on distance rowed during the maximal exercise test (main effect waist centile $F_{(1,99)} = 5.22$; $p = 0.025$). However, the effect of training was similar regardless of waist centile (there was no difference in improvement in distance rowed during the maximal rowing test between those who were above and below the 90th centile; time* group * waist centile, $p = 0.577$) (Table 3).

Training Effects- Blood metabolites

The six-week training intervention had no statistically significant effect on hs-CRP (main effect group, $p = 0.501$; time* group, p = 0.369), ALT (main effect group, $p = 0.470$; time* group, $p = 0.552$), AST (main effect group, $p = 0.688$; time* group, $p = 0.690$), total cholesterol (main effect group, $p = 0.214$; time* group, $p = 0.437$), HDL (main effect group, $p = 0.069$; time* group, $p = 0.385$), LDL (main effect group, $p = 0.748$; time* group $p = 0.913$), TAG (main effect group, $p = 0.143$; time* group, $p = 0.578$), and blood glucose concentrations (main effect group, $p = 0.717$; time* group, $p = 0.077$) (Table 4).

DISCUSSION

The first key finding of the present study is that 12–13-year-old males and females substantially improved their maximal rowing performance after a six-week rowing ergometer training program. The second key finding of the present study was that high intensity rowing ergometry training was effective at enhancing performance in overweight and obese participants, and that overall overweight and obese participants demonstrated superior rowing performance compared to normal weight children. Rate of perceived exertion was also lowered by training, in comparison with the controls, after a submaximal 3-minute bout of rowing at 60 W. Finally, high intensity rowing ergometry training did not improve any blood biomarkers of health in this cohort of adolescents.

A key novel finding of this investigation was that just 6-weeks of rowing ergometry training produced a significant improvement in maximal rowing performance and perceived effort in response to a set submaximal load (60 W). This is the first time that it has been demonstrated that high intensity rowing ergometry training improves these markers of physical fitness. Rate of perceived exertion during a submaximal exercise is an accurate and reliable predictor of peak oxygen uptake[37]. These improvements in submaximal RPE thus demonstrate that 6-weeks of high-intensity rowing ergometry training can improve overall physical fitness, as well as rowing specific performance. The improvements in these markers of physical fitness after just 6-weeks are likely accountable to the high intensity nature of the exercise training; the exercise training was completed at near maximal effort and hence provided a vigorous training stimulus. Previous literature has demonstrated the effectiveness of short-term high intensity training to improve fitness. One previous investigation demonstrated that just 6 high-intensity interval training sessions over 5 days improved maximal oxygen uptake and endurance capacity in adolescents[38]. High intensity interval training is a more time effective training strategy that has been shown to promote health benefits and improve fitness. Several meta-analyses report improvements in body composition[39] and cardiorespiratory fitness[14,39,40] in healthy young people and adults following high intensity interval training. However, evidence to support the use of high intensity interval training in overweight and obese young people is limited[41–43], and there is a distinct lack of evidence comparing the change in performance parameters in healthy weight, compared to obese young people.

The second key finding of this investigation was that adolescents who were overweight and obese responded to training similarly to those of a healthy weight; whilst overall, overweight and obese individuals had superior rowing performance compared to their healthy weight counterparts. This is the first time that high intensity rowing ergometry training has been assessed in a cohort of adolescents which included both adolescents with a healthy body mass and those classified as overweight or obese; allowing the examination of the effects of body mass on rowing performance to be examined. This is also the first study to demonstrate that untrained adolescents, who are not accustomed to rowing ergometry, perform similarly, and respond to training similarly, regardless of whether they are overweight and obese or classified as a healthy weight. The importance of this finding is that those who were overweight and obese performed better during the maximal rowing test compared to their counterparts who had a lower body mass. Because rowing ergometry is a non-weight bearing activity and performance is based upon power output, those who are heavier are actually at an advantage compared to their healthy weight counterparts. If young people feel competent at a sport or physical activity, they are more likely to enjoy that sport or physical activity, and thus are more likely to adhere to that sport or physical activity intervention. Therefore, rowing ergometer training represents a potential avenue to encourage those adolescents who are overweight and obese into physical activity. This is important because overweight and obese young people are often dissuaded from partaking in physical activity because they feel that they are at a disadvantage and underperform compared to their healthy weight counterparts, which results in a feeling of a lack of competency. Higher body mass has an adverse effect on perceived physical competence[22–25], and perceived competence has been suggested to mediate the relationship between actual competence and physical activity levels[44], including in clinically obese young people[45]. Young people with low levels of actual and perceived physical competence, such as those young people who are obese, may be less motivated to engage and persist in physical activities, resulting in fewer movement opportunities to improve their skilfulness and perception of competence[26]. Tailoring interventions to the abilities of the cohort (e.g., using non-weight baring modes of physical activity such as rowing ergometry in overweight and obese adolescents) may increase perceived competence[45]. Therefore, this study demonstrates the potential utility of rowing ergometry training to promote physical activity among young people, including those who are overweight and obese.

The key strength of this investigation is the novelty of the use of high intensity rowing ergometer training to improve physical fitness and performance in adolescents (aged 12-13 years) in a school setting. One of the potential limitations of this study was however the potential learning effect that may have occurred during the intervention period. While participants did not receive any coaching with regards to their rowing technique, participants may have improved their rowing technique over the course of the training programme, which could have accounted for some improvement in performance. However, while familiarity could have had some impact, RPE was also reduced during submaximal tests, which suggests that fitness was in fact improved and improvement was not simply a result of improved technique due to familiarity.

While this investigation was only 6-weeks in duration, which prevents exploration into the chronic effects of high intensity rowing ergometer training, this investigation is the still the first to investigate the effects of high intensity rowing ergometer training of any duration in a population of adolescents. However, future research should focus on exploring the chronic effects (e.g., 12-week intervention) of high intensity rowing ergometer training in this cohort with further exploration into the potential beneficial impacts on cardiometabolic health markers, especially in a sub-group of centrally obese adolescents. Future research may also benefit from longitudinal investigation to explore whether an introduction into rowing ergometer training in centrally obese young people tracks into these participants persisting with physical activity having found a physical activity modality at which they perform equally or superiorly to their healthy weight peers. Research should also examine whether the results of the present investigation are similar across a wider age range including older adolescents. This may be of particular importance when examining the female population. Many girls disengage from physical activity in their teens with self-belief, capability, and body image concerns highlighted as significant issues for all girls who choose to stop taking part in physical activity[46]. Therefore, if adolescent girls can be re-engaged by an activity that they feel competent and confident at this may have the potential to prevent disengagement or encourage re-engagement in physical activity.

CONCLUSIONS

In summary, in a cohort of 12- and 13-year-old males and females, six-weeks of high intensity rowing ergometer training in school PE lessons resulted in improved maximal and submaximal rowing ergometer performance as demonstrated by an increase total distance rowed in a 3- minute maximal test and reduced perceived effort in response to a submaximal exercise load. Furthermore, the adaptations in response to training were similar in obese and non-obese adolescents, and similar in girls as well as boys. Additionally, being heavier was associated with a higher total distance achieved in the 3-minute maximal test, which may be important for those who are overweight and obese to feel physically competent and confident in taking part in rowing ergometry and hence may be more likely to adhere to this exercise modality. Thus, rowing ergometer training may be a useful addition to physical education lessons and may potentially contribute to enhanced health in young people.

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Conflicts of interest

This study was funded by Concept2 Ltd. The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest. The results of the study are presented clearly, honestly, and without fabrication, falsification, or inappropriate data manipulation. The results of the present study do not constitute endorsement by the American College of Sports Medicine.

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FIGURE LEGENDS

Figure 1: Change in submaximal and maximal RPE and heart rate in the training and control groups.

Panels A-F display submaximal exercise testing variables, panels G-H display maximal exercise testing variables in the training group (---------) and the control group (———).

A. RPE post 60 watts (time* group, p = 0.040); **B.** RPE post 71 watts (time* group, p = 0.110); **C.** RPE post 86 watts (time* group, p = 0.270); **D.** HR post 60 watts (time* group, p = 0.886); **E.** HR post 71 watts (time* group, p = 0.465); **F.** HR post 86 watts (time* group, p = 0.270); **G.** RPE max (time* group, p = 0.094); **H.** HR max (time* group, p = 0.303).

Figure 2. Maximal distance rowed during the 3-minute maximal test in the training and control groups (time* group, p = 0.018).

Figure 1

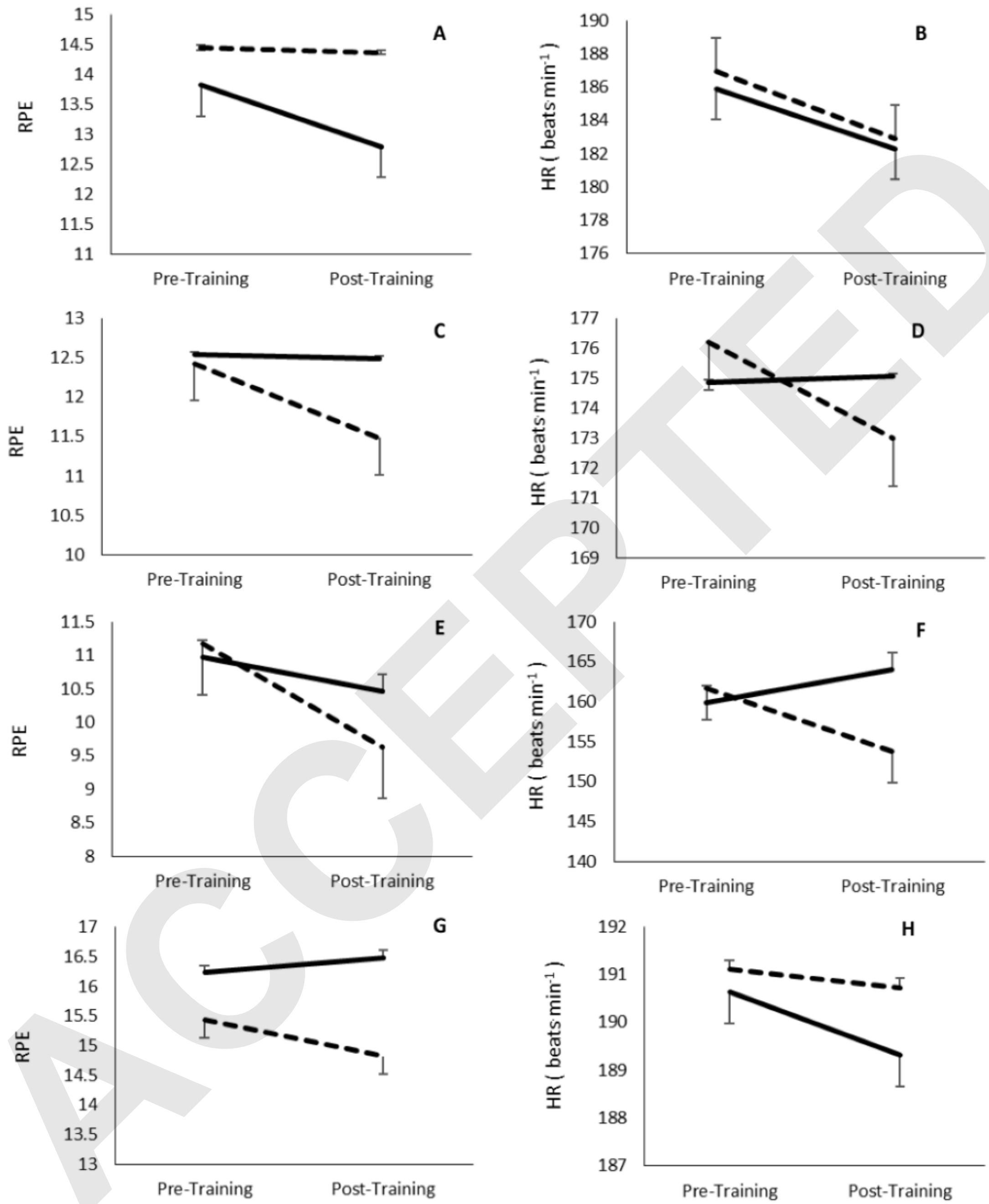
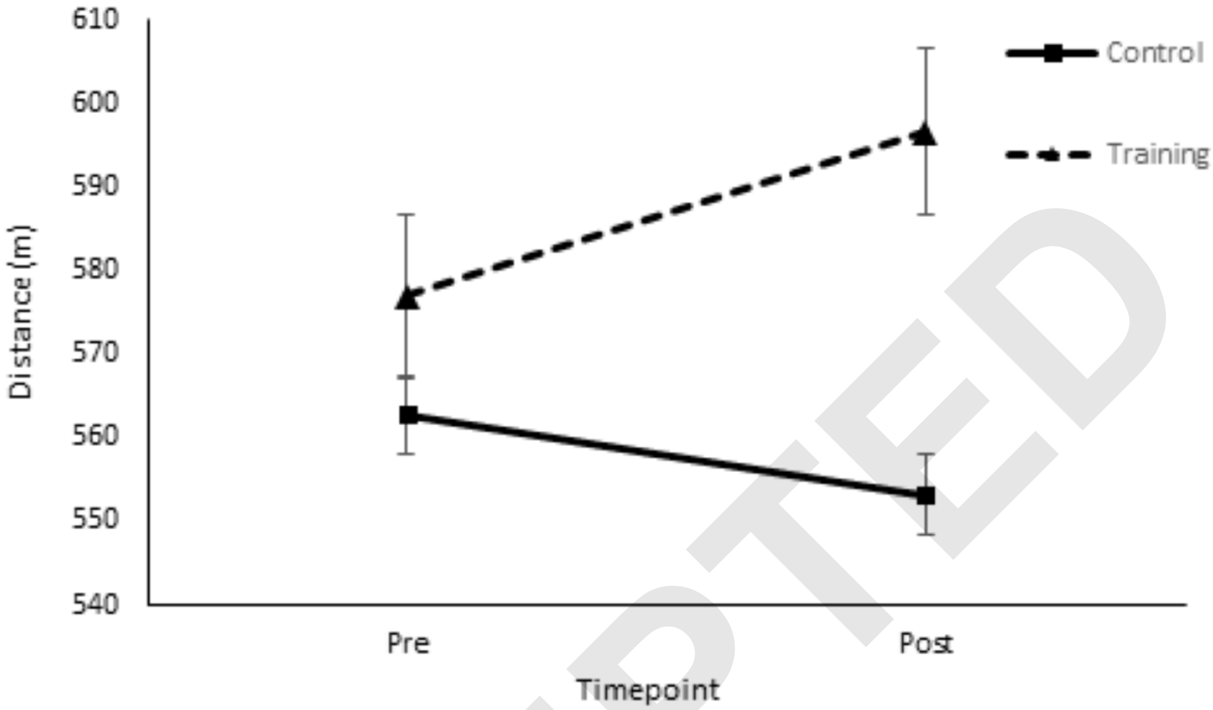


Figure 2



610
600
590
580
570
560
550
540
Distance (m)
Control
Training
Pre
Post
Timepoint

Table 1. Participant baseline characteristics

	Control	Training
n	45	57
Female (n)	33	32
Male (n)	12	25
Age (years)	12.63±0.32	12.63±0.33
Height (cm)	157.70±7.34	157.01±6.38
Body mass (kg)	51.78±12.70	51.98±9.53
BMI (kg/m^2)	20.65±4.02	21.03±3.35
Waist circumference (cm)	68.67±8.71	69.39±7.63

Table 2. Maximal and submaximal exercise testing results split per intervention group (training *vs* control).

	3-min maximal distance (m)	HR post 60 watts (beats·min⁻¹)	HR post 71 watts (beats·min⁻¹)	HR 86 post watts (beats·min⁻¹)	RPE post 60 watts	RPE post 71 watts	RPE post 86 watts
				Control			
Pre	562.8±54.9	122±20	133±18	138±13	11±2	13±2	14±3
Post	553.2±63.8	116±17	130±19	136±17	10±2	13±2	15±2
				Training			
Pre	576.9±63.9	118±18	128±21	136±18	11±2	12±3	14±3
Post	596.7±71.0 [a]	114±16	127±16	138±18	10±2 [b]	11±2	13±2

[a] time* group interaction, $F_{(1,97)} = 5.83$; $p = 0.018$.

[b] time * group interaction, $F_{(1,86)} = 4.40$; $p = 0.040$.

Table 3. Maximal and submaximal exercise testing results split per intervention group (training *vs* control) and per waist percentile (above 90% are classified as obese, below 90% are classified as non-obese)

	Control		Training	
	Pre	Post	Pre	Post
	Below 90%			
3-min maximal distance (m)	550.3±49.0	538.6±60.1	576.2±69.5	589.7±80.8
RPE post 60 watts	14±3.	14±2	14±3	13±2
RPE post 71 watts	13±2	13±2	12±3	11±2
RPE post 86 watts	11±2	11±2	11±2	9±2
HR post 60 watts (beats·min^{-1})	122±21	123±20	112±19	109±17
HR post 71 watts (beats·min^{-1})	136±18	135±18	122±21	122±17
HR post 86 watts (beats·min^{-1})	139±15	139±19	132±20	133±20
	Above 90%			
3-min maximal distance (m)	583.2±59.5	577.4±64.2	578.2±53.6	609.5±47.1
RPE 60 watts	14.8±2.8	14±2	14±2	13±2
RPE 71 watts	12.4±2.8	12±2	13±2	12±2.0
RPE 86 watts	11.1±2.8	10±2	12±2	10±2
HR post 60 watts (beats·min^{-1})	120±21	111±9	130±16	117±15
HR post 71 watts (beats·min^{-1})	124±16	129±14	140±15	134±14
HR post 86 watts (beats·min^{-1})	138±10	135±8	144±12	142±14

Table 4. Blood biomarkers pre- and post-training in the training and control groups

	hs-CRP (mg.L^{-1})	ALT (U.L^{-1})	AST (U.L^{-1})	Total Cholesterol (mmol.L^{-1})	HDL (mmol.L^{-1})	LDL (mmol.L^{-1})	TRG (mmol.L^{-1})	Blood Glucose (mmol.L^{-1})
	Control							
Pre	1.14±2.00	18.10±11.04	31.60±7.71	3.92±0.75	1.34±0.34	2.63±0.68	0.74±0.36	4.85±0.47
Post	0.94±1.51	15.94±2.33	29.05±3.61	4.24±0.75	1.48±0.39	2.78±0.75	0.84±0.43	5.03±0.64
	Training							
Pre	1.18±1.84	18.46±4.82	31.50±4.52	3.78±0.62	1.24±0.29	2.56±0.60	0.85±0.53	5.04±0.52
Post	1.40±2.15	17.29±6.64	29.53±4.99	4.05±0.73	1.32±0.31	2.75±0.70	1.05±0.92	5.19±0.70