Published in final edited form as:

Clin Pediatr (Phila). 2015 January ; 54(1): 87–90. doi:10.1177/0009922814528038.

The Feasibility of High Intensity Interval Exercise in Obese Adolescents

Anne Murphy^{1,2}, Christopher Kist, MS, HFS¹, Amanda J. Gier, MS¹, Nicholas M. Edwards, MD, MPH^{1,3}, Zhiqian Gao, MS⁴, and Robert M. Siegel, MD¹

¹Center for Better Health and Nutrition, Heart Institute, Cincinnati Children's Hospital Medical Center

²Medical Student Summer Research Program, University of Cincinnati, College of Medicine

³Division of Sports Medicine, Cincinnati Children's Hospital Medical Center

⁴Heart Institute Research Core, Cincinnati Children's Hospital Medical Center

Keywords

Obesity; Exercise; High Intensity Interval

Introduction

Exercise is a critical component in the management of pediatric obesity. Currently, continuous aerobic exercise (AE) is the standard of care for pediatric weight management programs. The 2008 Physical Activity Guidelines for Americans primarily promote aerobic activity for children, and aerobic-based exercise at a steady intensity (AE) is typically prescribed in pediatric weight management programs¹. Several studies in adults, however, show advantages of high-intensity interval exercise (HIIE) over continuous AE at improving fitness and health in both healthy and obese people^{2–4}.

These benefits of HIIE compared to AE have also been demonstrated in some limited studies in children. In a sample of healthy prepubescent children, Borel et al showed the immediate effects on oxygen uptake (VO₂) of HIIE to be comparable to continuous AE by continuously monitoring gas exchange of subjects at various points in an exercise protocol. Farpour et al showed improved health and fitness measures in healthy children as a result of HIIE^{5,6}.

Some of this work in children extends into the obese population. Ingul et al showed that impaired cardiac function in obese adolescents can be improved by 3 months of HIIE training on a treadmill twice a week for 13 weeks⁷. Tjonna et al studied obese adolescents in twice weekly HIIE intervention for 12 weeks compared to subjects receiving bimonthly education from multidisciplinary health professionals⁸. HIIE was superior to educational classes at improving subject BMI, body fat, blood pressure, blood glucose, and endothelial

function. A study from the Sao Paulo School of Medicine compared HIIE and AE in obese 8–12 year old children with treadmill training protocols twice a week for 12 weeks. Both were found to be equally effective in improving aerobic fitness, insulin sensitivity, and BMI in obese children but the study may have had too few enrolled to show a difference between modes of exercise⁹.

While these few studies of HIIE in obese children have shown benefits on fitness and cardiovascular risk factors, the acceptability and enjoyment of this protocol in children is not clear. Enjoyment of the exercise is a crucial component if our goal is long-term adherence. Another limitation of many HIIE studies in children is restriction of the interval training to treadmill protocols; a more varied exercise protocol would be more comparable to the current standard of care, which includes group games and more variable equipment choices. The purpose of this HIIE study was to measure the enjoyment and acceptability of HIIE as well as the feasibility of a multimodal protocol in obese teenagers enrolled in a multi-disciplinary pediatric weight management program as a precursor for a larger, definitive study.

Methods

Adolescents with BMI at or above the 95th percentile for age and sex were recruited from a multi-disciplinary pediatric weight management program at a large academic medical center. All subjects were between 12 and 18 years of age. Exclusion criteria included the following: taking medication that may affect the heart rate and/or blood pressure, inability to exercise for any reason, pregnancy within 6 months, stage 2 hypertension, and history of significant cardiac disease leading to cardiovascular instability.

The intervention group and control groups were enrolled and completed sequentially; ten obese adolescents were recruited for the HIIE group and then 8 were recruited for the AE group. The intervention group received four weeks of HIIE training and the control group received the standard pediatric exercise classes, consisting of traditional aerobic exercise. All participants were required to attend at least 3 of 4 structured 50-minute exercise sessions each week for 4 weeks. Subjects present for at least 3 exercise sessions per week received a ten dollar gift card at the end of each week.

The control exercise protocol included: 50 minutes of supervised aerobic exercise (AE) with a regimen consisting of a 10-minute warm-up, 30 minutes of relatively continuous aerobic exercise at 65% of estimated exercise capacity, and a 10 minute cool down period. Participants wore a portable heart rate monitor and were observed by the study exercise physiologists to ensure that effort was maintained at 65%.

The following protocol was used for HIIE group sessions: a 10 minute warm-up, 30 minutes of HIIE with 10 cycles of 1 minute vigorous exercise at 80 to 90% maximum heart rate followed by 2 minutes of active recovery at 60% maximum heart rate, and 10 minutes of cool-down. Participants wore a portable heart rate monitor and were observed by the study exercise physiologists to ensure that effort was maintained at target heart rate goals throughout the session. The protocols were designed to be consistent with published exercise

intensity definitions, consistent with previously studied protocols, and comparable to each other in terms of energy expenditure.⁶⁻⁸

Physiologic and anthropometric data of subjects in both groups was obtained at entry and after completing the 4-week intervention. Evaluation of fitness included $\text{VO}_{2\text{max}}$ test and $\text{VO}_{2\text{sub-max}}$ (at 6 and 9 minutes) testing on the treadmill using Cosmed k4B2 Mobile Cardiopulmonary Exercise Test equipment (Cosmed USA Inc., Chicago Ill) following a modified Bruce Protocol. To assess body composition, weight and height were used to calculate BMI and body fat was determined via bioelectrical impedance using a HBF-306C Body Fat Analyzer (Omron Healthcare, Inc. Lake Forest Illinois).

At the end of the intervention, participants in the HIIE group completed a satisfaction survey to compare their experience with their previous experience with the traditional exercise program.

All analyses were done using SAS (ver. 9.3, SAS Institute, Inc., Cary, North Carolina). Descriptive statistics were summarized as frequency for categorical variables; mean, standard deviation for continuous variables by groups. Paired T-test was performed to compare changes pre- and post-intervention of each group. T-test was performed to compare values between intervention groups. A *p*-value less than 0.05 was considered significant.

The study was approved by the Cincinnati Children's Hospital Institutional Review Board.

Results

In the intervention group, 9 teens consented to participate, 2 attended no exercise sessions and 7 completed the study; the mean age of those in the HIIE group was 13.7 years (Table 1). Five of the 7 were female and 4 were African American. Six out of 7 subjects attended every required session of exercise; the mean attendance rate was 95%. In the control group, 8 teens consented to participate and 6 completed the study with a mean age of 14.4 years. Five of the 7 were female and 6 were African American. The average attendance was 11.3 of 16 sessions for both groups.

Both the HIIE and AE group showed improvement in $\text{VO}_{2\text{max}}$ with the AE significant for VO_2 max per kg, and the HIIE significant when indexed to fat free mass¹⁰. Neither group demonstrated a significant change in BMI or in percent body fat.

Seven of 8 HIIE participants completed the satisfaction survey. All 7 reported they would "recommend this type of exercise program to a friend." Six out of 7 participants responded they desired "to continue with the same type of exercise program." When asked "overall, how would you rate" the four-week exercise program on a scale from 0–100, the average response was 85. All 7 responded they were able to hit their "heart rate goals most of the time." The AE group was not surveyed.

Discussion

With our feasibility study we demonstrate that obese teens can be successfully recruited and complete a pilot study of HIIIE. Retention of subjects was satisfactory and participants reported satisfaction with HIIIE. The use of HIIIE exercise classes in obese teens was shown to be structured, realistic, and highly desired. Using small incentives for attendance was an effective method of subject participation in both groups.

As this was a feasibility study, there were many limitations which include small sample size, lack of randomization, and short duration of intervention. Only the HIIIE was surveyed for acceptability. Still, our study demonstrates that teens find HIIIE acceptable and that such a study comparing the two modes is feasibility. Both AE and HIIIE led to an improvement in fitness as in previous studies.

Future research is warranted to determine the relative effect of HIIIE versus standard exercise in obese children. In this study the intervention period of 4 weeks was not expected to lead to significant physiologic change in subjects. A study with more subjects and more substantial intervention periods, such as 12 or more weeks of exercise, is necessary to demonstrate significant physiologic change in submaximal and maximal VO_2 , BMI, and body fat.

Acknowledgement

We gratefully acknowledge that this study was supported in part from a MSSRP Grant (NIH grant T35 DK 60444), in part by the National Center for Research Resources and the National Center for Advancing Translational Sciences (NIH Grant KL2 TR000078) and done with the help and expertise of the Cincinnati Children's Heart Institute Research Core. The content is solely the responsibility of the authors and does not necessarily represent the official views of the NIH.

References

1. United States Dept. of Health and Human Services. 2008 physical activity guidelines for Americans : be active, healthy, and happy!. Washington, DC: U.S. Dept. of Health and Human Services; 2008.
2. Mensink GB, Heerstrass DW, Neppelenbroek SE, Schuit AJ, Bellach BM. Intensity, duration, and frequency of physical activity and coronary risk factors. *Med Sci Sports Exerc.* 1997; 29:1192–1198. [PubMed: 9309631]
3. Paffenbarger RS, Lee IM. Intensity of physical activity related to incidence of hypertension and all-cause mortality: an epidemiologic view. *Blood Press Monit.* 1997; 2:115–123. [PubMed: 10234104]
4. Tjonna AE, Lee SJ, Rognmo O, Stolen TO, Bye A, Haram PM, Loennechen JP, Al-Share QY, Skogvoll E, Slordahl SA, Kemi OJ, Najjar SM, Wisloff U. Aerobic interval training versus continuous moderate exercise as a treatment for the metabolic syndrome: a pilot study. *Circulation.* 2008; 118:346–354. [PubMed: 18606913]
5. Borel B, Leclair E, Thevenet D, Beghin L, Berthoin S, et al. Correspondences between continuous and intermittent exercises intensities in healthy prepubescent children. *Eur J Appl Physiol.* 2010; 108:977–985. [PubMed: 19960352]
6. Farpour-Lambert NJ, Aggoun Y, Marchand LM, Martin XE, Herrman FR, Beghetti M. Physical activity reduces systemic blood pressure and improves early markers of atherosclerosis in pre-pubertal obese children. *J Am Coll Cardiol.* 2009; 54:2396–2406. [PubMed: 20082930]
7. Ingul C, Tjonna A, Stolen T, Stoylen A, Wisloff U. Impaired Cardiac Function Among Obese Adolescents: Effect of Aerobic Interval Training. *Arch Pediatr Adolesc Med.* 2010; 164:852–859. [PubMed: 20819968]

8. Tjonna AE, Stolen TO, Bye A, Volden M, Slordahl SA, Odegard R, Skpgvoll E, Wisloff. Aerobic interval training reduces cardiovascular risk factors more than a multitreatment approach in overweight adolescents. *Clin Sci*. 2009; 116:317–326. [PubMed: 18673303]
9. Corte de Araujo AC, Roschel H, Picanço AR, do Prado DML, Villares SMF, et al. Similar Health Benefits of Endurance and High-Intensity Interval Training in Obese Children. *PLoS ONE*. 2012; 7:1381–1388. e42747.
10. Goran M, Fields DA, Hunter GR, Herd SL, Weinsier RL. Total Body fat does not influence maximal aerobic capacity. *IJO*. 2000; 24:841–848.

Table 1Clinical Characteristics of Study Population and Pre/Post variables (values are $\pm$ one standard deviation).

Variable	HIEE (N=7)	Standard AE (N=6)	P Value
Age	13.7 $\pm$ 2.0	14.3 $\pm$ 1.2	0.52
Gender, n (%)			
Male	2 (29%)	1 (17%)	NA
Female	5 (71%)	5 (83%)	NA
Race, n (%)			
Black or African American	4 (57%)	5 (83%)	NA
White	3 (43%)	1 (17%)	NA
Average Exercise Visits	11.4	11.2	NA
SBP (mmHg)	117.4 $\pm$ 3.4	123.3 $\pm$ 6.8	0.07
DBP (mmHg)	64.6 $\pm$ 5.0	66.7 $\pm$ 4.1	0.43
Height (cm)	165.3 $\pm$ 8.6	170.4 $\pm$ 11.4	0.37
Weight (kg)	89.6 $\pm$ 25.5	106.3 $\pm$ 20.1	0.22
Body Mass Index (kg/m ²)			
Baseline	32.5 $\pm$ 7.6	36.4 $\pm$ 4.7	0.29
End	32.6 $\pm$ 7.1	36.4 $\pm$ 4.5	0.28
Change	0.119 $\pm$ 0.887	-0.048 $\pm$ 0.615	0.71
% Body Fat			
Baseline	37.9 $\pm$ 3.6	39.7 $\pm$ 1.6	0.3
End	38.3 $\pm$ 3.7	41.5 $\pm$ 2.3	0.1
Change	0.327 $\pm$ 1.06	1.750 $\pm$ 2.66	0.22
VO _{2max} (ml/kg/min)			
Baseline	29.1 $\pm$ 3.5	26.8 $\pm$ 4.9	0.34
End	32.7 $\pm$ 4.0	30.2 $\pm$ 2.6	0.31
Change	2.70 $\pm$ 2.97	2.99 $\pm$ 1.72*	0.87
VO _{2max} indexed to lean mass (ml/kg/min) ¹⁰			
Baseline	46.9 $\pm$ 4.7	44.5 $\pm$ 8.2	0.52
End	51.8 $\pm$ 5.5	50.9 $\pm$ 3.7	0.78
Change	4.43 $\pm$ 4.19*	5.27 $\pm$ 3.42	0.75
9 minute submaxVO2 (ml/kg/min)			
Baseline	21.6 $\pm$ 3.2	21.4 $\pm$ 2.0	0.92
End	21.1 $\pm$ 3.0	22.3 $\pm$ 4.8	0.63
Change	-0.450 $\pm$ 4.48	0.537 $\pm$ 4.10	0.73
9 minute submaxVO2(ml/kg/min, indexed to lean mass)			
Baseline	34.7 $\pm$ 4.1	35.7 $\pm$ 3.0	0.66
End	34.4 $\pm$ 5.1	37.5 $\pm$ 7.9	0.43
Change	-0.375 $\pm$ 7.06	1.15 $\pm$ 6.52	0.73

NA =Not applicable

*
p<0.05 for changes from baseline.