University of Cincinnati

Date: 3/8/2019

I, Adam Z Magier, hereby submit this original work as part of the requirements for the degree of Master of Science in Nutrition.

It is entitled:

Design and Process Evaluation of a High Intensity Interval Training Program for Adolescents who are Overweight or Obese and are Enrolled in a Multi-modal Intervention

Student's name: **Adam Z Magier**

This work and its defense approved by:

Committee chair: Sarah Couch, Ph.D.

Committee member: Abigail Peairs, Ph.D.

33013

Design and Process Evaluation of a High Intensity Interval Training Program for Adolescents who are Overweight or Obese and are Enrolled in a Multi-modal Intervention

A thesis submitted to the

Graduate School of the University of Cincinnati

in partial fulfillment of the requirements for the degree of

Master of Science

in the Department of Rehabilitation, Exercise and Nutrition Sciences

of the College of Allied Health Sciences

at the University of Cincinnati

Adam Zachary Magier

B.S., University of Cincinnati, 2016

Committee Chair, Sarah Couch, Ph.D., RD, LD

Committee Member, Abigail Peairs, Ph.D.

ABSTRACT

Adolescent obesity is a major health issue requiring increased attention from medical providers. Adolescents who are overweight or obese experience higher rates of comorbidities including insulin resistance, non-alcoholic fatty liver disease, type 2 diabetes, and cardiovascular disease in comparison to their normal weight peers. Various dietary and exercise plans have proven effective for adolescent weight management, including high intensity interval training (HIIT), which is a specific form of exercise where maximal-effort bouts are alternated with less intense periods of recovery. Programs designed to initiate lifestyle changes, in combination with behavioral modification approaches, are essential in combatting this epidemic; however, best practices for helping adolescents who are overweight and obese achieve a sustained healthy weight remain elusive.

PURPOSE: To examine the acceptability of a HIIT program designed to be initiated in combination with a calorie controlled DASH diet plan in a clinical setting with telehealth follow-up for overweight and obese adolescents.

METHODS: The HIIT exercise protocol was developed through conducting a comprehensive review of the literature, consultation with pediatric exercise experts, and pilot testing for feasibility. Professional videography was utilized to create videos of the exercise routines, which were provided only to patients enrolled in the study. Participants were enrolled in a 12-week intervention to assess the effects of the Dietary Approaches to Stop Hypertension (DASH) diet combined with HIIT when delivered via telehealth. A process questionnaire was administered at the end of the 12-week intervention to gain feedback from participants about the acceptability of the intervention.

RESULTS: The recruited population was consistent with the target population with an average weight percentile of 93.8 (±2.53). The average BMI percentile was 98.8 (±0.77) and a majority of the participants met criteria for severe obesity. Several comorbidities were also present in the recruited population. One-hundred percent of participants completed the process questionnaire, and 87.5% attempted the HIIT protocol at least once. The program was rated as "good" overall and there were more aspects that were liked than disliked. A majority of participants indicated that they would continue with the exercises after completing the study and one-hundred percent stated they would recommend the program to a friend.

CONCLUSION: This HIIT protocol was specifically designed for adolescents with elevated weight status. Overall, it was positively reviewed by participants and may offer an exciting alternative to traditional aerobic endurance exercise, such as moderate intensity training. The program was designed to address the commonly reported barrier of time constraint, and the length was shorter in duration than other HIIT programs designed for this population. This was especially important given that this is the first HIIT program to be delivered to this population via telehealth. Important design features also include no equipment, minimizing costs associated with purchasing exercise materials, and video delivery of the program, which allows participants to complete this in a comfortable setting of their choice, including the home.

TABLE OF CONTENTS

Abstract	ii
Background Information	1
Research Question and Hypothesis	5
Methods	5
Results	21
Discussion	28
References	36

LIST OF TABLES AND FIGURES

Table 1	10
Figure 1	13
Table 2	15
Table 3	16
Table 4	21
Table 5a	22
Table 5b	23
Table 5c	24
Table 5d	25
Table 6	27

BACKGROUND INFORMATION

Adolescent obesity is a rapidly growing epidemic both in the United States and across the globe. It is a major public health problem with adverse health consequences. According to the Centers for Disease Control (CDC), the adolescent obesity rate has increased from 10.5% to 13.9% from 2001 to 2015, and rates of obesity appear to be trending upwards.[1] Combined with an increase in the rate of overweight among adolescents, which has risen from 13.6% to greater than 16% in the same time period, nearly one in three children age 11 to 17 has a body mass index (BMI) above normal.[1] Adolescents with increased weight status are at elevated risk for chronic diseases including insulin resistance, non-alcoholic fatty liver disease (NAFLD), hypertension, type 2 diabetes, cardiac disease, and other and related risk factors, [3,4,6,9-12] and are predisposed to psychosocial problems such as low self-esteem and depression.[2-9] This growing health epidemic can most commonly be attributed to caloric imbalance however genetic and hormonal factors, physical inactivity, psychosocial and environmental factors, and rare pathophysiologic causes may be at play.[3,6,10]

Given the extensive comorbidities resulting from pediatric and adolescent obesity, there is evidence that several of these consequences can be treated with effective nutrition and exercise interventions, herein referred to as behavioral interventions when prescribed concurrently.[2,4,11-13] With effective exercise interventions in obese adolescents, bone health, cardiovascular health, school performance and psychosocial health can all be improved.[14,15] Favorable effects of behavioral interventions have been consistently reported with a program duration of at least 12 weeks and a minimum of 24 total, non-continuous hours of contact provided periodically throughout the entire intervention. [11,16] Exercise is an imperative component of weight

management and there are seemingly endless ways to incorporate exercise plans when designing interventions, making it challenging to find the best approach.

High Intensity Interval Training (HIIT) is an exercise program that can be adapted to suit several different types of exercise, including weight training, running, cycling, and more. The foundation of this training style is the theory of engaging in maximal effort and exertion for very brief periods, usually only 20-30 seconds, followed by an active recovery period, of which the length differs based on the objective and fitness level of the person performing the exercise. There is emerging evidence that HIIT is an effective and time efficient approach to improving the health of overweight and obese adolescents.[13,17,18] Despite heterogeneity and inconsistency across trials targeting adolescents, in comparison to a duration of moderate intensity exercise, properly performed HIIT at half of said duration has been shown to be as effective in improving cardiorespiratory fitness, systolic blood pressure, maximal oxygen uptake and HOMA-IR, but not waist circumference or muscular fitness.[17-20] Intervention duration was shown to be a moderator for these changes.[17-19] In adults, both HIIT and moderate intensity exercise significantly reduced whole-body fat mass and waist circumference, which differs from the observed results in adolescents.[21,22] Studies in youth indicate that no significant differences in body composition measures were observed between moderate and high intensity exercise plans, with both forms of exercise showing improvements from baseline. However, it is notable that HIIT required roughly 40 percent less training time commitment than moderate intensity exercise to see these benefits, suggesting that HIIT may be a more time-efficient component of weight management programs for adolescents.[17-19,21,22] Evidence indicates that HIIT has the potential to decrease weight and improve adverse health outcomes in overweight and obese adolescents.

Various HIIT protocols have been trialed in adolescents, including a pilot study to examine the acceptability of HIIT in adolescents who are obese.[13] Murphy et al. delivered a 4-week HIIT program, in person, to obese adolescents. Ten participants were recruited to the HIIT group, nine consented, and seven completed the study, while eight participants were recruited to moderate intensity training (control), and six consented. Eight participants randomized to HIIT attended 3-4 sessions weekly with an instructor and seven completed the exit survey. The HIIT protocol consisted of 1 minute high intensity bouts and 2 minutes of active recovery performed 10 times for a total of 30 minutes. The post-study survey results were favorable to HIIT, as 100 percent of participants indicated that they would "recommend this exercise program to a friend". This study demonstrated that HIIT could be administered safely in person with supervision; however, the extent to which participants would comply with a HIIT protocol if delivered online without weekly supervision has not been reported.

In general, telehealth and eHealth interventions, which involve the delivery of health related interventions via phone and internet, respectively, have been shown as promising delivery modalities for various types of interventions across diverse populations, including behavioral interventions for adolescents.[23-26] The Dietary Approaches to Stop Hypertension (DASH) diet is a healthy dietary pattern that emphasizes high intake of fruits and vegetables, and moderate consumption of low fat dairy and other lean protein foods, and is a program that has been delivered to teens via telehealth.[12] Couch et al., first delivered the DASH Diet program (called DASH-4-Teens) to adolescents with hypertension.[12] The DASH-4-Teens program was rooted in the social cognitive theory and promoted adolescent self-efficacy through the use of progressive,

achievable goal setting, action planning, skill building and self-monitoring.[12] Additional empirical evidence reporting on adolescents with elevated blood pressure has shown that a DASH diet can be appropriately planned to achieve weight loss and/or stability in youth and prevent age associated changes in blood pressure. [27,28] Nourse et al., later enhanced the DASH-4-Teens protocol and utilized Skype to deliver the 12-week DASH-4-teens program with moderate intensity exercise training to adolescents who were overweight and obese.[24] DASH-4-teens involved one Skype diet and exercise counseling session and 10 behaviorally-oriented follow-up Skype contacts. Nourse et al., showed that the DASH-4-teens program was effective in reducing systolic blood pressure and improving other cardiovascular and cardio-metabolic risk factors in adolescents who were overweight and obese.[12,24]

The results of the combined dietary and exercise intervention delivered via telehealth by Nourse et al. had a high retention rate of participants and good compliance to treatment in terms of the reported number of dietary and exercise goals met by participants over the course of the trial. This is encouraging but there is a need for additional studies to determine the most effective modality to increase compliance with intervention prescription of behavioral interventions.

There is also a need for more multimodal behavioral interventions that promote self-efficacy in lifestyle behaviors related to sustained weight management in adolescents who are overweight and obese.[29] The health benefits and rates of compliance of individual components of multimodal behavioral intervention approaches differ; however, there is evidence that both HIIT and the DASH dietary program can be effectively delivered to adolescents. Further, delivery of HIIT via telehealth may result in a high level of program retention and adherence that will be conducive to

favorable changes in anthropometric measures, diet quality, and metabolic indicators of cardiovascular health and fitness.

RESEARCH QUESTION AND HYPOTHESIS

What is the acceptability of a high intensity interval training (HIIT) program in combination with a calorie controlled DASH diet plan initiated in a clinical setting with telehealth follow-up for overweight and obese adolescents?

We hypothesize that participants will be able to complete the HIIT program successfully in a home environment and that at least three-fourths of participants will review the program favorably.

METHODS

For this thesis project, a HIIT protocol was developed for overweight and obese adolescents and acceptability of this protocol accessed. The rationale for the HIIT design and the steps involved in developing the approach are detailed below.

Rationale for HIIT protocol design

According to the United States Department of Health and Human Services (USDHHS) Second Edition of Physical Activity Guidelines for Americans, HIIT is defined as a method of training in which exercise bouts of maximal-effort are alternated with less intense periods of recovery.[30] These guidelines, which are also accepted by the American College of Sports Medicine (ACSM), designate bouts as periods of activity that are designed to be performed at 80-90% maximal heart rate (MHR). Interspersed recovery periods are designed to allow the heart rate to return to 50-

70% MHR. There is no universally accepted form of HIIT as duration of bouts and recovery, total length of a protocol, number of repeated cycles, and capacity quantifying maximal-effort, all differ across exercise designs. The HIIT methodology can be applied to numerous types of activities for different target populations.

Through a compilation of data and several systematic analyses, the USDHHS has quantified a minute of HIIT as the equivalent of two minutes of moderate intensity training.[30] Additionally, this group supports the voluminous literature indicating HIIT as a highly effective form of exercise to reduce cardiovascular disease risk factors. Furthermore, the USDHHS recommends adolescents complete 60 minutes of moderate-to-vigorous physical activity daily, combining a mix of aerobic, muscle-strengthening, and bone-strengthening exercises.[30]

There are a variety of barriers to exercise that are commonly reported by adolescents who are obese. A systematic review by Kebbe et al. reported barriers to physical activity in adolescents who are obese at the individual, interpersonal, environmental and policy levels.[31] Time constraint is a large barrier at both the individual and interpersonal levels. Personal and parental scheduling conflicts as well as "using lack of time as an excuse" were common reasons cited for inadequate exercise.[31] Furthermore, de-prioritization and psychosocial factors (lack of enjoyment, self-consciousness, perceived incompetence, and previously failed attempts at weight loss) were common reasons for disinterest in exercise provided by adolescents who are obese. [31] At the interpersonal level, disinterest because of perceived lack of support from family and peers (social networks) was cited as a major barrier.[31] The rationale for HIIT to be utilized in this population stems from the potential to address both time and disinterest as two of the major individual and

interpersonal barriers. Considering the aforementioned factors, our intention was to design a program that was both engaging and challenging for adolescents, could be completed within a short-time frame and allowed for the teen to improve and progress over time. Toward this end, incorporation of different types of activities to stimulate interest was considered essential.

Important Design Considerations for this HIIT protocol

For this particular protocol, we took into consideration guidelines from the USDHHS and ACSM,[30] the commonly reported barriers to exercise,[31] and factors that would enable feasibility in a hospital-based clinic operation. The following factors were deemed essential elements in the design of an exercise program for youth who are overweight or obese treated in a clinic setting:

1. Exercise Combination: Incorporation of aerobic, muscle-strengthening, and bone-strengthening exercises requiring no equipment
2. Safety: The target population commonly has limited mobility, requiring selection of exercises that are safe to perform if unsupervised
3. Delivery: The protocol must be able to be delivered via telehealth and be concise for ease of delivery in a clinic setting.
4. Retention: The protocol should be challenging but allow room for growth with progression. The initial difficulty should not deter participants from continuing.

Designing the Protocol

Comprehensive review of the literature led to the identification of several studies of previous HIIT protocols.[13,18-21] Due to the diversity in exercises available, these protocols varied tremendously with different cardiovascular and strength training exercises, interval and total time

durations, frequencies, recovery methods, and protocol lengths. After consultation with experts in exercise prescription for adolescents who are overweight or obese at Cincinnati Children's Hospital Medical Center (CCHMC), we developed a pilot HIIT protocol addressing the aforementioned considerations. First, the protocol was designed to incorporate a variety of body weight exercises that could be safely performed by the target population. Second, videos were created for participants to follow in a home environment. Lastly, the protocol was designed to include multiple phases with increasing difficulty, but that consistently maintained a positive active recovery time.

Pilot Feasibility

A HIIT protocol was designed and first tested in a small pilot study, which was approved by the Institutional Review Board at the University of Cincinnati. The primary objective was to determine the feasibility and acceptability of this HIIT exercise regimen for college students between 18 and 20 years of age. We enrolled 4 participants in the pilot study and conducted one, face-to-face exercise session per week for 6 weeks. Three participants completed at least 4 of the 6 sessions held. All participants wore heart rate monitors during the sessions so that determination of active and recovery heart rate could be made. Preliminary data showed that the heart rate patterns throughout this duration were consistent with HIIT for all participants, as heart rate was elevated above 80% MHR during bouts, and returned to 50-70% MHR during the active recovery.

After establishing feasibility of the HIIT exercises for the target age group, we proceeded to develop this exercise regimen into a program that could be delivered online, developed a face-to-

face brief instructional component, and then administered the program in combination with a dietary counseling session in a clinic-setting for adolescents who were overweight or obese. The program, here-to-fore referred to at the DASH-IT program, was tested as part of a randomized clinical trial that will be detailed below. This thesis will report on the specifics of the online HIIT program and acceptability data about the program from the adolescents that were part of the larger randomized control trial, the DASH-IT study.

HIIT Protocol Design for the DASH-IT study

Table 1 depicts the entire HIIT routine for the DASH-IT program. In all 3 phases, bouts were designed to last for 30 seconds, and active recovery time to decrease across the three phases. As part of our design considerations, we recognized that as cardiovascular fitness increases, participants would need a more challenging level of exercise. Participants were instructed to complete a total of 6 bouts and 6 periods of active recovery with each exercise day. All bouts were 30 seconds in duration. To increase the difficulty of the program without changing the structure or number of bouts, active recovery decreased from 60, to 50, to 40 seconds in phases 1, 2, and 3, respectively. Cumulatively, the total duration of the HIIT program (including bouts and active recovery periods) is only 9, 8, and 7 minutes in phases 1, 2, and 3, respectively. Participants were instructed to complete each phase for 4 weeks, before moving on to the next phase, for a total of 12-weeks in the DASH-IT study.

Table 1

Phase 1 – Day 1		Phase 1 – Day 2		Phase 1 – Day 3	
Exercise	Time	Exercise	Time	Exercise	Time
High Knees	30sec	X Jumps	30sec	Wall Sprints	30sec
Side to side	60sec	Side to side	60sec	Side to side	60sec
Jumping Jacks	30sec	Wide Plank Hand Touch	30sec	Modified Burpees	30sec
March in Place	60sec	March in Place	60sec	March in Place	60sec
Down Dog Walk Back	30sec	Mountain Climbers	30sec	Down Dog Walk Back	30sec
4 steps forward, 4 back	60sec	4 steps forward, 4 back	60sec	4 steps forward, 4 back	60sec
Repeat 1x		Repeat 1x		Repeat 1x	

Phase 2 – Day 1		Phase 2 – Day 2		Phase 2 – Day 3	
Exercise	Time	Exercise	Time	Exercise	Time
High Knees	30sec	X Jumps	30sec	Wall Sprints	30sec
Side to side	50sec	Side to side	50sec	Side to side	50sec
Jumping Jacks	30sec	Wide Plank Hand Touch	30sec	Modified Burpees	30sec
March in Place	50sec	March in Place	50sec	March in Place	50sec
Down Dog Walk Back	30sec	Mountain Climbers	30sec	Down Dog Walk Back	30sec
4 steps forward, 4 back	50sec	4 steps forward, 4 back	50sec	4 steps forward, 4 back	50sec
Repeat 1x		Repeat 1x		Repeat 1x	

Phase 3 – Day 1		Phase 3 – Day 2		Phase 3 – Day 3	
Exercise	Time	Exercise	Time	Exercise	Time
High Knees	30sec	X Jumps	30sec	Wall Sprints	30sec
Side to side	40sec	Side to side	40sec	Side to side	40sec
Jumping Jacks	30sec	Wide Plank Hand Touch	30sec	Modified Burpees	30sec
March in Place	40sec	March in Place	40sec	March in Place	40sec
Down Dog Walk Back	30sec	Mountain Climbers	30sec	Down Dog Walk Back	30sec
4 steps forward, 4 back	40sec	4 steps forward, 4 back	40sec	4 steps forward, 4 back	40sec
Repeat 1x		Repeat 1x		Repeat 1x	

Each day was crafted to include a variety of exercises, which allowed for utilization of multiple muscle groups, enhancing the benefits of the workout. Day 1 consisted of an aerobic exercise (High Knees), an aerobic/bone strengthening exercise (Jumping Jacks), and a muscle strengthening exercise, (Down Dog Walk Back). Day 2 consisted of an aerobic/bone strengthening exercise (X-Jumps), a muscle strengthening exercise (Wide Plank Hand Touch) and an aerobic/muscle strengthening exercise (Mountain Climbers). Day 3 consisted of an

aerobic exercise (Wall Sprints) a bone/muscle strengthening exercise (Modified Burpees) and a muscle strengthening exercise (Down Dog Walk Back).

To ensure the safety of participants while exercising, a warm-up was developed to be completed before the exercise session and a cool-down was designed to be completed after the exercise session concluded. Each of these was 5 minutes in duration. The warm up consisted of 5 exercises, each performed for 30 seconds and then repeated. The exercises included: Side to Side Reaches, Twists, Calf Raises, Leg Swings, and Hurdles. The cool down consisted of 3 exercises, performed for various durations (specified in parentheses) and were completed only once: Pigeon Pose (90 seconds), Frog Pose (90 seconds), and Corpse Pose (120 seconds).

Protocol Implementation

Addressing the need for telehealth delivery for clinical implementation, instructional videos were created for each of the HIIT phases as described above. These videos featured two young adult fitness professionals performing the exercises as demonstrations for the teens to follow at home. The intention of this instructional delivery method was to ensure proper demonstration of each exercise. In the video one of the instructors demonstrated each exercise and the other narrated the instructions for the exercise and stressed body position, intensity and stop and start time. A time clock was also incorporated into the video so that the participants would know when to stop and start the HIIT exercises and recovery exercises. In addition, to enhance the quality of the videos, open source (non-copyrighted) music without lyrics was selected for each video.

Accompanying the exercise videos, a two-page handout (Figure 1) was developed to provide participants with a comprehensive summary of the exercises within each HIIT phase. Both a paper and an electronic copy of the handout was provided to each participant, and hyperlinks to the exercise videos were included within the document. Each participant was provided a face-to-face 10-15 minute instructional session detailing the program plan in the clinic. Participants were shown how to follow the handout, how to access the private YouTube video hyperlinks, and offered the opportunity to have each of the HIIT exercises demonstrated by the research coordinator.

Figure 1

DASH-IT Exercise Routine

Always complete the **Warm Up** for 5 minutes to help prepare your muscles for exercise.
Always complete the **Cool Down** for 5 minutes to help relax your muscles after exercise.
Complete the exercises **at least 3 different days** each week.

As the study continues, you will become more conditioned and the exercises will become easier.
To keep the exercises fun and challenging, the active rest time becomes slightly shorter.

- Phase 1 occurs during weeks 1-4 of the study. The HIIT exercise lasts for 9 minutes.
- Phase 2 occurs during weeks 5-8 of the study. The HIIT exercise lasts for 8 minutes.
- Phase 3 occurs during weeks 9-12 of the study. The HIIT exercise lasts for 7 minutes.

Exercise Instructions

Warm Up: Side to Side Reaches, Twists, Calf Raises, Leg Swings, Hurdles
Complete each exercise for 30 seconds. Repeat sequence one time (1x)
Cool Down: Pigeon Pose (90 seconds), Frog Pose (90 seconds), Corpse Pose (120 seconds)

Phase 1 – Day 1	
Exercise	Duration
High Knees	30 sec
Side to side	60 sec
Jumping Jacks	30 sec
March in Place	60 sec
Down Dog Walk Back	30 sec
4 steps forward, 4 back	60 sec
Repeat 1x	
tiny.cc/DASH-IT-P1-D1	

Phase 1 – Day 2	
Exercise	Duration
X Jumps	30 sec
Side to side	60 sec
Wide Plank Hand Touch	30 sec
March in Place	60 sec
Mountain Climbers	30 sec
4 steps forward, 4 back	60 sec
Repeat 1x	
tiny.cc/DASH-IT-P1-D2	

Phase 1 – Day 3	
Exercise	Duration
Wall Sprints	30 sec
Side to side	60 sec
Modified Burpees	30 sec
March in Place	60 sec
Down Dog Walk Back	30 sec
4 steps forward, 4 back	60 sec
Repeat 1x	
tiny.cc/DASH-IT-P1-D3	

Phase 2 – Day 1	
Exercise	Duration
High Knees	30 sec
Side to side	50 sec
Jumping Jacks	30 sec
March in Place	50 sec
Down Dog Walk Back	30 sec
4 steps forward, 4 back	50 sec
Repeat 1x	
tiny.cc/DASH-IT-P2-D1	

Phase 2 – Day 2	
Exercise	Duration
X Jumps	30 sec
Side to side	50 sec
Wide Plank Hand Touch	30 sec
March in Place	50 sec
Mountain Climbers	30 sec
4 steps forward, 4 back	50 sec
Repeat 1x	
tiny.cc/DASH-IT-P2-D2	

Phase 2 – Day 3	
Exercise	Duration
Wall Sprints	30 sec
Side to side	50 sec
Modified Burpees	30 sec
March in Place	50 sec
Down Dog Walk Back	30 sec
4 steps forward, 4 back	50 sec
Repeat 1x	
tiny.cc/DASH-IT-P2-D3	

Phase 3 – Day 1	
Exercise	Duration
High Knees	30 sec
Side to side	40 sec
Jumping Jacks	30 sec
March in Place	40 sec
Down Dog Walk Back	30 sec
4 steps forward, 4 back	40 sec
Repeat 1x	
tiny.cc/DASH-IT-P3-D1	

Phase 3 – Day 2	
Exercise	Duration
X Jumps	30 sec
Side to side	40 sec
Wide Plank Hand Touch	30 sec
March in Place	40 sec
Mountain Climbers	30 sec
4 steps forward, 4 back	40 sec
Repeat 1x	
tiny.cc/DASH-IT-P3-D2	

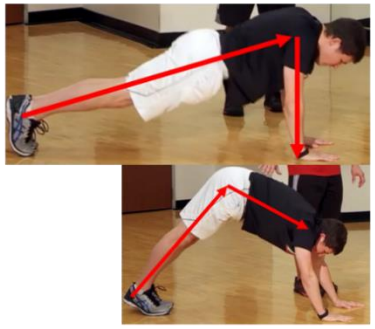
Phase 3 – Day 3	
Exercise	Duration
Wall Sprints	30 sec
Side to side	40 sec
Modified Burpees	30 sec
March in Place	40 sec
Down Dog Walk Back	30 sec
4 steps forward, 4 back	40 sec
Repeat 1x	
tiny.cc/DASH-IT-P3-D3	

If you need help with your HR Monitor, please read the **instruction manual**: tiny.cc/DASH-IT-HR-Monitor
Always wear your **Heart Rate Monitor** when performing exercises.

A) High Knees

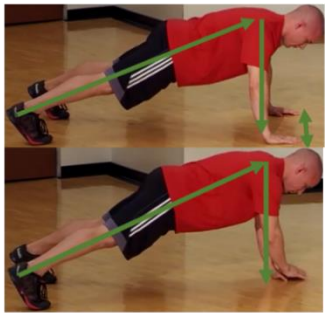
B) Jumping Jacks

C) Down Dog Walk Back

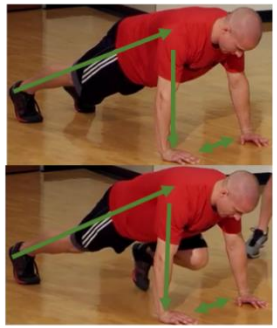


D) X Jumps

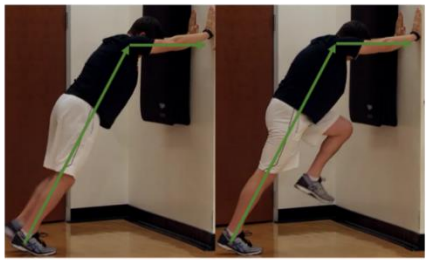
E) Wide Plank Hand Touch



F) Mountain Climbers



G) Wall Sprints



H) Modified Burpees

Conducting the DASH-IT Study in the HealthWorks! Clinic

The Center for Better Health and Nutrition (also known as *HealthWorks!*) at CCHMC serves pediatric patients with elevated weight, by providing medical care and recommendations for dietary and exercise changes. *HealthWorks!* graciously allowed the DASH-IT study team to pilot test the DASH-IT diet and exercise intervention as an alternative approach to their standard of care, described by Hipsky and Kirk in 2002.[32] Standard of care included a comprehensive primary care visit with a staff physician and interdisciplinary counseling sessions on the Stop Light Diet (termed the Healthy Eating Plan (HEP)),[33] provided by a staff dietitian, and moderate intensity exercise videos, provided by a staff exercise physiologist. There was no telehealth follow-up for participants who received standard of care.

To mirror the interdisciplinary approach of the *HealthWorks!* clinic, this HIIT protocol was incorporated with a dietary intervention that focused on a calorie-controlled Dietary Approaches to Stop Hypertension (DASH) dietary pattern for weight management (the DASH-IT Study). Instructions for the DASH diet and the HIIT protocol were delivered in a face-to-face session by a study dietitian (DASH diet) and a study personal trainer (HIIT protocol) as part of a multi-modal intervention. In the larger randomized clinical trial the 12-week DASH intervention, including a face-to-face counseling session and 10 follow-up phones, was compared against a DASH reduced protocol (face-to-face counseling with no follow-up contacts) and the standard of care. The study design for this larger randomized trial is described in Table 2.

Table 2: Study Randomization Groups

	DASH-IT Intervention	**DASH-IT Reduced**	**Standard Care**
Diet	DASH	DASH	HEP (Stop-Light)
Exercise	HIIT Videos	HIIT Videos	*HealthWorks!* Videos
Behavioral Modification	Telehealth weekly phone calls	No weekly contact	No weekly contact

Participants: Recruitment and Enrollment

HealthWorks! clinic schedules were screened by one clinical research coordinator (CRC) with assistance from the principal investigator (a *HealthWorks!* physician) when needed. Patients meeting enrollment criteria (defined in Table 3) were contacted by the CRC over the phone and/or in clinic. Patients were encouraged to enroll prior to the visit through an electronic informed consent form (e-consent), which was sent to participants via the secure texting platform Twillio, a platform integrated to the secure research database, RedCap (V8.1.2, Vanderbilt University, 2018). Participants were also provided the option to wait until their scheduled clinic visit to enroll in the study.

Once a patient arrived in clinic, a *HealthWorks!* physician counseled the patient and ensured eligibility criteria and safety for study participation. If eligible, and a patient had not yet enrolled in the study via the e-consent method, they were again invited to participate informed consent was obtained by a designated CRC. Enrolled participants were then randomized to intervention group and were provided with the corresponding intervention plan.

Table 3: Eligibility Criteria

Inclusion Criteria	*Exclusion Criteria*
• Age 12-17, based on patient reported birth date • Weight in the 85th percentile or higher, as assessed by weight-for-age guidelines • Self-reported access to both a smartphone, and Wi-Fi internet • Sedentary Lifestyle, as assessed through weekly screen time and exercise • Readiness to change, as assessed through a 1-question Readiness to Change questionnaire • New patient of *HealthWorks!* or a reassessment patient who has not attended a follow up appointment within the previous 4 months, and has ≤3 visits in the previous 3 years)	• Self-reported non-exertional shortness of breath • Current enrollment in any extracurricular organized physical activity or sporting team or self-reported moderate intensity activity exceeding 150 minutes per week. • Any musculoskeletal, cardiovascular, pulmonary, or orthopedic problems or disabilities precluding physical activity. • Stage II Hypertension • Insulin-Dependent Diabetes • Previously diagnosed Left Ventricular Hypertrophy • New prescription of stimulant within previous 12 months with continuous usage • Current use of psychotropic agents • Current use of medication for hypertension or body weight management. • Current enrollment in another behavioral intervention or interventional research study • Physician exclusion for any reason indicated*

*Physician exclusion encompassed a number of diagnoses and other conditions including eating disorders, patients in gender transition, and educational or developmental delay.

Interventions:

For the DASH-IT Interventions, one of two study dietitians delivered the initial DASH diet counseling (depending on availability) and a single CRC/personal trainer delivered the HIIT instruction. Participants randomized to standard care received dietary and then exercise counseling from a staff dietitian and staff exercise physiologist, respectively. After meeting with the *HealthWorks!* physician, 100 percent of participants attended a face-to-face counseling session for dietary (25-30 minutes) followed by an exercise intervention (10-15 minutes). According to their randomization group, participants were provided a dietary manual on either the DASH diet or the Stop-Light Diet, and an exercise handout for the HIIT intervention with YouTube channel links to the HIIT videos or *HealthWorks!* moderate intensity exercise video links.

HIIT Protocol Implementation in the DASH-IT Study

Participants were instructed in clinic by a CRC/personal trainer to complete the exercise program at least 3 times weekly for the duration of the 12-week study. Further, they were instructed to participate in each of the 3 phases for 4 weeks. Participants randomized to the DASH-IT Intervention group were contacted with 8 weekly phone calls and then two biweekly phone calls for a total for 10 contact calls throughout the 12-week study. These telehealth calls were centered on behavioral modifications and goal setting. Participants set 3 dietary goals and 1 exercise goal with the phone counselor each week. The phone counselor ensured that the participants in this

group advanced through the exercise program at the designed pace of 4 weeks per phase. A single study dietitian completed all of the intervention phone calls. DASH-IT reduced group also had access to the HIIT videos, but did not receive weekly counseling phone calls.

A total of $10 could be earned by all participants at the initial study visit for completing up to three, 24-hour food recalls ($2/call, $6 total) and $4 for attendance at the nutrition and dietary counseling session. These values were doubled ($4/call and $8 for attendance) for conclusion study visit at the end of the 12-week intervention, providing the potential for participants to earn an additional $20. For participants randomized to the DASH-IT Intervention group only, an additional $48 could be earned, $1 for each of the goals set during the 12 week program.

Process Questionnaire

After conclusion of the 12-week DASH-IT Program, participants were asked to complete a process questionnaire, or exit survey, in order to provide feedback about the program. This questionnaire, administered electronically via Twillio and RedCap, was designed to measure the acceptability of the dietary, exercise, and telehealth components of the program and included open text boxes for personal comments and feedback on the program. This thesis focused on the HIIT program and will report responses to those questions corresponding to the HIIT program and open text feedback about the exercise intervention (which could be provided in either the exercise section or the telehealth section). Ten questions specifically related to participants' impression of different aspects of the HIIT exercise program. Participants were asked to rate particular components of the program using a scale slider, ranging from 0-10, where 0 is poor, 2 is average, 5 is good, 8 is great, and 10 is excellent. Two questions related to what a participant

"liked" and "disliked" about the intervention protocol. These questions utilized a format where participants could choose from multiple options, allowing investigators to capture information about various aspects of the program in a concise format. These options remained consistent between both questions and included the following:

a. The length of the exercise sessions in the video
b. The fact that no exercise equipment was required
c. The way I felt after I exercised
d. The exercise instructions provided in the video)
e. The exercises included in each session
f. The cool down activities
g. Other*

*The option "Other" opened a free-text field for the participant to respond.

Four questions directly assessed the acceptability of the HIIT videos. The questions captured participants' perceptions about the length of the video exercise session, the choice of exercises included in each session, the instructions provided at the beginning of the video, and the instructions provided during each exercise session. Each of these questions was evaluated using a 5 point Likert scale. The questions and answer options were grouped under question "What did you think about the following parts of the exercise portion of this program":

1. The length of each video exercise session?
    a. Way too short
    b. A little short
    c. Perfect length
    d. A little long
    e. Way too long
2. The choice of exercises included in each session?
    a. I really disliked the exercises
    b. I sort of disliked the exercises

c. I neither liked nor disliked the exercises
d. I sort of liked the exercises
e. I really liked the exercises

3. The instructions for the exercises at the beginning of the video?
   a. I really disliked the instructions provided
   b. I sort of disliked the instructions provided
   c. I neither liked nor disliked the instructions provided
   d. I sort of liked the instructions provided
   e. I really liked the instructions provided
4. The exercise instructions provided during each exercise session?
   a. I really disliked the instructions
   b. I sort of disliked the instructions
   c. I neither liked nor disliked the instructions
   d. I sort of liked the instructions
   e. I really liked the instructions

Three additional questions used Yes/No/Don't Know options and further assessed program acceptability by addressing the length of exercise and recovery, continuation with HIIT after completing the study, and recommending the program to a friend.

RESULTS

Baseline characteristics of the study population are shown in Table 4. A majority of the participants were Caucasian females. On average, the participants were severely obese with elevated blood pressure. Various comorbidities, commonly associated with severe obesity, were also present amongst the group.

Table 4: Descriptive Statistics

	Total (n=8)
Age	
Average	14.64 (±1.71)
12-14 years	6 (75%)
15-17 years	2 (25%)
Sex	
Female	6 (75%)
Male	2 (25%)
Race	
White	6 (75%)
African American	1 (12.5%)
Hispanic	1 (12.5%)
Blood Pressure	
Systolic	114.25 (±8.62)
SBP Percentile	64.88 (±23.14)
Diastolic	67.92 (±10.99)
DBP Percentile	56.13 (±29.19)

	Total (n=8)
Anthropometrics	
Height	161.1 (±7.26)
Height Percentile	50.05 (±32.85)
Weight	93.34 (±14.62)
Weight Percentile	98.3 (±2.53)
BMI*	35.86 (±4.3)
BMI Percentile	98.8 (±0.77)
BMI % of 95th Percentile**	131.25 (±15.72)
Percent Body Fat	45.35 (±4.81)
Comorbidities	
Stage 1 Hypertension	2 (25%)
Elevated Liver Enzymes	3 (37.5%)
Asthma	2 (25%)
Snoring	3 (37.5%)
Depression/Anxiety	4 (50%)

*BMI = body mass index

**BMI % of 95th percentile is a measure obtained from the extended growth chart. Severe obesity is defined as a BMI greater than 120% of the 95th percentile.

Table 5: Measures of Acceptability

Tables 5a-d show data on compliance and acceptability of the HIIT component of the DASH-IT program.

Table 5a shows a high-level of compliance among participants with responding to the study process questionnaire and 87.5% of the participants reporting that they attempted the HIIT protocol at least once.

Table 5a: Overall Compliance (n=8)

Participants completed process questionnaire	8 (100%)
Participants never attempted HIIT	1 (17%)
Participant withdrawals	1 (17%)

*All 8 participants responded to the survey. One participant indicated that they never once completed the protocol. That report has been excluded from analysis.

Table 5b shows the overall perception of acceptability the HIIT protocol. Based on the average scale score, participants' overall perception of the program was "good" acceptability.

Table 5b: Overall Program Rating	Total (n=7)
Overall, how would you rate your experience with the exercise part of the DASH-IT program?	5.4 (3-8)

*Data is reported as Average (Range). The provided scale ranged from 0-10 and was defined as 0=poor, 2=average, 5=good, 8=great, 10=excellent.

Table 5c shows process results on overall HIIT program acceptability. Based on the overall percentages of participants reporting on elements of the program that they liked compared to disliked, it can be deduced that more aspects of the program were liked by participants than disliked. The length of the exercise sessions in the video was the only component that participants disliked more than they liked. As shown in table 5d, two of these participants noted that the exercise protocol was "a little short", while one made indicated that "it was too long". Notably, 71% of participants indicated that they would participate in HIIT in the future, and 100% of participants indicated that they would recommend the HIIT program to a friend.

Table 5c: Overall Acceptability		Total (n=7)
What were some of the things you liked about the exercise program?	*The length of the exercise sessions in the video*	3 (43%)
	The fact that no exercise equipment was required	4 (57%)
	The way I felt after I exercised	3 (43%)
	The exercise instructions provided in the video)	3 (43%)
	The exercises included in each session	3 (43%)
	The cool down activities	4 (57%)
What were some of the things that you did not like about the exercise program?	*The length of the exercise sessions in the video*	4 (57%)
	The fact that no exercise equipment was required	---
	The way I felt after I exercised	---
	The exercise instructions provided in the video)	---
	The exercises included in each session	2 (29%)
	The cool down activities	1 (14%)
Did you like the length of time for exercise and recovery?	*Yes*	4 (57%)
	No	2 (29%)
	Don't Know	1 (14%)
Do you think you'll continue with this type of exercise program after finishing the study?	*Yes*	5 (71%)
	No	---
	Don't Know	2 (29%)
Would you recommend this type of exercise program to a friend?	*Yes*	7 (100%)
	No	---
	Don't Know	---

*Data is reported as Number of Responses (Percent of Group)

Table 5d summarizes perceptions on acceptability of the HIIT videos. Overall, participants reported that the protocol was of an acceptable length for adolescents beginning their weight management efforts. Two of the participants declared the protocol "a little short", and one declared it to be "a little long". These 3 responses were also captured in the question relating to protocol length in Table 5c. Most participants "sort of liked the exercises" and all of the participants "liked" or "really liked" the instructions presented throughout the videos.

Table 5d: Acceptability of Videos		Total (n=7)
What did you think about the length of each video exercise session?	*A little short*	2 (29%)
	Perfect Length	4 (57%)
	A little long	1 (14%)
What did you think about the choice of exercises included in each session?	*I neither liked nor disliked the exercises*	2 (29%)
	I sort of liked the exercises	5 (71%)
What did you think about the instructions for the exercises at the beginning of the video?	*I sort of liked the instructions*	5 (71%)
	I really liked the instructions	2 (29%)
What did you think about the exercise instructions provided during each exercise session?	*I sort of liked the instructions*	5 (71%)
	I really liked the instructions	2 (29%)

*Answer choices provided were on a Likert scale. Response options are only included if at least one participant selected the option. Please refer to the methods section for the complete set of answer choices.

Table 6 provides open text responses from participants in the DASH-IT program. Response 1 was from the participant who did not complete the exercise videos. Therefore, evaluation of program acceptability from this participant was of limited utility. Response 2 was from a participant who dropped out of the program after only completing 2 intervention phone calls over 4 weeks. As evident in the comment, this comprehensive intervention was overwhelming for this particular teen. The responses from all other participants were favorable. Specifically, response 3 and 5 were from participants in the intervention group and both favorably reviewed the weekly counseling calls as a way to stay motivated and updated with the program. Responses 4 and 6 also provided positive feedback about the HIIT program sharing the belief that this could help their friends and that the program resulted in weight loss for the participants. Ultimately, it appears that counseling calls may be beneficial in helping to keep some participants on track, but some thought of them as overwhelming.

Table 6: Open Text Responses to HIIT component of DASH-IT program

Participant (DASH-IT Group)	**Response**
Participant 1 (Reduced)	Never opened the videos. No effort was put into them and I forgot about them.
Participant 2 (Intervention)	I felt pressure and stress with the calls sometimes because I know I didn't do what I said I would and didn't want to have to talk about it. Everyone was nice and it was good things to do it just got really stressful adding tracking to my schedule and it felt like everything anyone talked to me about including my parents was food and exercise constantly and it made me not want to do it at all.
Participant 3 (Intervention)	Yes I would recommend for someone who is starting and needs a convenient fast exercise program but for someone who is more advanced it can start to be too easy and slow. Sometimes since I am more accustomed to exercise I didn't feel like I was sweating or really working out with these exercises. I really liked having weekly phone calls. The weekly calls gave me the most motivation because I knew that if I didn't do a log or if I was unsuccessful that week that I would have to speak with [the phone counselor] at the end of the week with no information to give her.
Participant 4 (Reduced)	I like this program and I think it could help some of my friends just like it helped me.
Participant 5 (Intervention)	It's a very fun way to exercise. The phone calls are very efficient for the study. They kept me on track each week.
Participant 6 (Reduced)	My weight has decreased and the instructions given were very detailed and easy to follow.

DISCUSSION

Emerging evidence on HIIT suggests that this form of exercise can be used as a means of improving cardiovascular fitness in a variety of populations. In the present study, our research team designed a unique HIIT protocol coupled with a dietary intervention program for enhancing cardiovascular health in adolescents who are overweight and obese. The HIIT program was designed to be delivered via a private YouTube channel for easy access. Our data on acceptability of the program suggested that over half of the participants liked the fact that no exercise equipment was necessary, enjoyed the cool down activities, and favored the length of time for exercise and recovery. The overall program rating was a 5 out of 10, where 5 indicated good acceptability. All participants indicated that they would recommend the program to a friend and a majority indicated that they would continue with the exercises after completing the study. Mixed reviews of the program were related to the length of the HIIT exercise sessions, the HIIT exercise instructions and the types of exercises included in the program, which may speak to a need to do a slower progression in the exercise phases with a more detailed instruction period in clinic. These findings suggest that a HIIT program initiated in clinic with online video follow-up, coupled with a dietary intervention program targeting weight management may be an acceptable approach to engaging overweight and obese adolescents in healthy lifestyle behaviors.

From an operational standpoint the DASH-IT program was easy to administer as part of standard clinic procedures in the *HealthWorks!* clinic. A typical clinic visit begins with a nurse-led assessment for vitals and body composition. Next, patients see a physician, dietitian, and exercise physiologist, but practitioner order varies between patients based on clinic flow, in an effort to maximize time efficiency of visits. When possible, the physician is the first to meet with

a patient, especially for new patient consultations. The physician performs a physical examination and conducts motivational interviewing to learn about patient-specific barriers and health issues related to weight gain and other pertinent comorbidities. A 25-30 minute, dietitian-led dietary counseling session and a 10-15 minute, exercise physiologist-led exercise counseling session are ideally the next two components of the clinic visit. The exercise physiologist is also responsible for administering a fitness test, which typically lasts between 5-10 minutes. New patient visits typically last 90-120 minutes, of which at least 60 minutes is devoted to lifestyle management from the three practitioners.

The DASH-IT intervention followed this same clinic flow and medical content delivery. All enrolled participants first met with a physician to ensure study eligibility. For patients randomized to either the DASH-IT Intervention or DASH-IT Reduced groups, the DASH dietary counseling occurred for 25-30 minutes, followed by HIIT exercise instruction for an additional 10-15 minutes. The telehealth follow-up for the DASH-IT Intervention group allowed participants to gain a deeper understanding of the DASH diet and HIIT program and learn behavioral skills for adoption of the intervention plans without adding any additional clinic time for content delivery. As evidence of clinical feasibility of the program, 100% of participants who were randomized to DASH-IT were able to obtain dietary and exercise counseling sessions within the allotted clinic time.

For this study, recruited participants had no previous exposure to a formal exercise program as part of our eligibility criteria. Most of the participants randomized to DASH-IT engaged in little to no exercise on a daily basis. The finding that half of the participants did not like the length of

the exercise session and felt that it was too long may speak to the degree of difficulty in progressing from no or limited activity to a 20-25-minute exercise session for some. A previous HIIT study in a pediatric population also recruited participants with no history of exercise intervention.[20] This study reported on clinical outcomes of HIIT compared to moderate intensity training but did not survey participants about their perception of the exercise program. Other studies, which have surveyed participants to gather information about program design, have not specified previous attempts at exercise intervention or used formal exercise exposure as exclusion criteria.[13,34,35] One pilot study on HIIT (HIP4YOUTH) included 12 participants who were enrolled in a previous exercise intervention under the same investigators.[36] Uniquely, this is the only study to report 100% completion rate from participants with no dropouts.[36] Ten out of 12 participants favorable rated the HIIT program, and 7 out of 12 preferred HIIT to the previous moderate intensity training program in which they were enrolled.[36] Specific reasons that participants did not enjoy the program or did not favor HIIT over moderate intensity training were not reported. The DASH-IT study targeted new clinic patients, or patients with minimal history of follow-up visits in the *HealthWorks!* clinic. A consideration for a subsequent trial with the DASH-IT intervention might be to target clinic patients who have already engaged in some form of low or moderate intensity exercise program. Patients that have familiarity with any form of exercise might appreciate the benefit of shorter session duration with HIIT, and this might potentially lead to increased acceptability of the program.

In comparison to other HIIT programs analyzing acceptability, the results from our study are fairly consistent. In the HIIT pilot study conducted by Murphy et al., 7 out of 8 participants completed the exit survey, all of which said they would recommend HIIT to a friend, and 6 out

of 7 stated they would enjoy continuing HIIT in the future.[13] This parallels our findings: 8 out of 8 or our participants completed the survey, and all but one engaged in the HIIT exercises. Of the 7 reliable acceptability responses (those that actually did HIIT), all 7 participants stated they would recommend HIIT to a friend and 5 or the 7 said they would continue with this exercise in the future. Of note, the remaining two participants indicated that they "[didn't] know" if they would continue this exercise in the future, but did not select the option "No" for this question. One of these participants explained in the open text responses that the program was "too easy and slow" and actually desired a more challenging program in the future. This participant further elaborated that he/she would recommend this particular HIIT protocol to someone beginning their weight management efforts and who was looking for a time efficient option. The HIIT component of the DASH-IT program received an overall rating of "good", the same rating for protocols described by Murphy et al. and Herget et al.[13,35] The overall impression of this HIIT program by all eight survey respondents was positive and our findings are consistent with other investigators in this field.

The handout provided to study participants on the HIIT exercises (Figure 1) showed the complete delivery of the protocol, with embedded links unique for each of the nine YouTube exercise videos. Notably, this two-page document was designed to be concise, which was an intentional choice made by the research team to ensure that the handout could be thoroughly reviewed within 15 minutes during the exercise counseling portion of the *HealthWorks!* clinic visit. The researchers also felt that it was important that the exercise videos included detailed instruction that could be followed by an unsupervised adolescent. Participant feedback about the video instructions was captured in two, 5-point, Likert scale questions on the process

questionnaire. Five out of 7 participants indicated that they "sort of liked the instructions" at the beginning of the videos and during the videos, while the remaining two indicated that they "really liked the instructions". Despite the fact that none of the participants indicated that they disliked the instructions, there is room for improvement in the design of the instructional aspects of the videos to have a higher percentage of responses indicating the highest value on the Likert scale. A focus group of HIIT participants to address this program weakness would provide valuable insight on this aspect of the program.

Similarly, the protocol could be improved in regards to choices of exercises included in the videos. The exercises selected for this protocol were based on those that required no equipment and could be completed in a limited space, like a living room. Our research group tested the exercises with the target population on several occasions, inserting them into a moderate intensity exercise class at CCHMC, and we determined that the participants could perform the exercises without issue and appeared to enjoy the experience. In the present study, using a 5-point Likert scale, participants in this study were surveyed about the types of exercises in DASH-IT. Five out of 7 participants indicated that they "sort of liked the exercises", while the remaining 2 indicated that they "neither liked nor disliked the exercises". One way to increase the enjoyment of the specific exercises would be to hold a focus group or initiate a pre-study survey to capture information from the target population about specific exercises they would enjoy. Taylor et al. demonstrated this method by completing a series of pilot studies when designing the Fun Fast Activity Blasts (FFAB) HIIT exercise program for adolescents.[37] Surveyed students were asked to indicate specific types of exercises they would enjoy completing in an effort to maximize enjoyment and subsequently attendance and compliance during the in-person exercise

session.[37] The HIIT component of the DASH-IT plan could be enhanced moving forward if patients within the *HealthWorks!* clinic completed surveys indicating preferred types of exercises and the most highly preferred were then included in the program.

In the open text responses, 2 of the participants receiving follow-up phone calls in the DASH-IT Intervention group commented on the helpfulness of the calls to keep them on track with the diet and exercise. In fact, they attributed their success with exercise and dietary compliance to the weekly check-in phone calls. A key component of the DASH-IT full program was enhancing the self-efficacy of participants through weekly accountability checks. Enhancing self-efficacy, which is a major tenet of the social cognitive theory of behavior change, appeared to have been important for some DASH-IT participants and may have contributed to their health enhancement. Joseph et al. included components of the social cognitive theory in designing an internet-enhanced physical activity pilot program for African American, college aged females.[38] These researchers found that participants with higher baseline physical activity levels were more likely to favorably rate and complete the program.[38] Interestingly, self-efficacy of participants decreased over the duration of the 3-month study, suggesting an area for program improvement in future trials.[38] A more recent study enrolled 12 young adult males and 12 middle aged men, with a sedentary lifestyle, in a randomized cross-over trial comparing self-efficacy of HIIT to moderate intensity continuous exercise and vigorous intensity continuous exercise.[39] All interventions were done in a supervised setting, and participants were presented with a self-efficacy questionnaire one hour after the exercise was completed. Interestingly, the young participants reported increased self-efficacy with HIIT compared to the other two forms of exercise, but the older participants showed reduced self-efficacy. Reasons for this finding are

unclear. Literature specific to self-efficacy with HIIT in adolescents is limited; therefore future iterations of the DASH-IT intervention should intend to measure self-efficacy as an outcome, as it may be an important factor in program compliance and success.

As part of the DASH-IT program, all participants were provided the HIIT instructional handout and shown clips of the HIIT exercise videos. The HIIT program was explained and any questions were answered by the research study staff. Participants were also provided the option of completing each of the eight HIIT exercises with a staff member or of receiving a demonstration of each exercise. Not all participants engaged in this option and in hindsight, making the exercise instruction mandatory may have enabled the staff to make sure that all participants understood how to do the exercises and the importance of the exercises before leaving the clinic. One participant even indicated "I forgot about them" in regards to the exercise videos, suggesting that perhaps more time may be needed to emphasize the importance of exercising in combination with diet to achieve maximal success in the DASH-IT program.

Limitations of this study include small sample size, and an inability to determine compliance to the HIIT at home. The study did purchase heart rate monitors to track compliance to HIIT. Unfortunately these did not work consistently and the data could not be used to assess compliance to exercise. Future trials should ensure that compliance measures are in place to determine whether teens actually engaged in HIIT. Another limitation is that there was a competing study in the clinic which had first pass at screening the clinic schedules, leaving our group with less volume and patients who were potentially less motivated. Additional barriers to recruitment stemmed from the method of enrollment. With the expectation that three 24-hour

dietary recalls would be completed before intervention began, the study initially required informed consent to be obtained prior to the clinic visit so that calls could be completed. More than 60% of participants contacted prior to the visit who verbally agreed over the phone to receive the electronic consent document did not complete the e-consent process and thus became ineligible. After 4 weeks of recruiting with this method, the study team agreed to amend the recruitment plans to allow for informed consent to be obtained in clinic, and one dietary recall would be performed before intervention and a second would be completed the day following intervention initiation. The utilization of both recruitment methods greatly enhanced enrollment as the study progressed, but did pose a limitation in the ability to collect baseline dietary information.

In conclusion, the HIIT component of the DASH-IT intervention was deemed acceptable by study participants. The program was rated as "good" overall and there were more aspects that were liked than disliked. Also, most participants declared that they would continue HIIT after the study, and all would recommend it to a friend. This pilot study found several areas in need of improvement, such as the types of exercises chosen for the program and the instructions throughout the video. If revisions were made for future iterations of the program, it would be important to obtain participant input prior to any changes. In addition, it would be important to pre-screen participants for an appropriate level of difficulty of exercise, and consider increasing bout duration, and/or decreasing active recovery time for those that show improved fitness quickly in the program. Monitoring change in fitness status of participants would be important for fine tuning of the HIIT protocol. Future interventions should explore self-efficacy of HIIT in this population, and in particular study the impact of accountability in program success.

REFERENCES

1. CDC.gov. Adolescent Obesity Rates. https://nccd.cdc.gov/dnpao_dtm/rdPage.aspx?rdReport=DNPAO_DTM.ExploreByTopic&islClass=OWS&islTopic=OWS1&go=GO, 1 April 2018.
2. Bass R, Eneli I. Severe childhood obesity: an under-recognised and growing health problem. *Postgraduate medical journal.* 2015;91(1081):639-645.
3. Gurnani M, Birken C, Hamilton J. Childhood Obesity: Causes, Consequences, and Management. *Pediatric clinics of North America.* 2015;62(4):821-840.
4. McCrindle BW. Cardiovascular consequences of childhood obesity. *The Canadian journal of cardiology.* 2015;31(2):124-130.
5. Sanders RH, Han A, Baker JS, Cobley S. Childhood obesity and its physical and psychological co-morbidities: a systematic review of Australian children and adolescents. *European journal of pediatrics.* 2015;174(6):715-746.
6. Kumar S, Kelly AS. Review of Childhood Obesity: From Epidemiology, Etiology, and Comorbidities to Clinical Assessment and Treatment. *Mayo Clinic proceedings.* 2017;92(2):251-265.
7. Alper Z, Ercan I, Uncu Y. A Meta-Analysis and an Evaluation of Trends in Obesity Prevalence among Children and Adolescents in Turkey: 1990 through 2015. *Journal of clinical research in pediatric endocrinology.* 2018;10(1):59-67.
8. Quek YH, Tam WWS, Zhang MWB, Ho RCM. Exploring the association between childhood and adolescent obesity and depression: a meta-analysis. *Obesity reviews : an official journal of the International Association for the Study of Obesity.* 2017;18(7):742-754.

9. Umer A, Kelley GA, Cottrell LE, Giacobbi P, Jr., Innes KE, Lilly CL. Childhood obesity and adult cardiovascular disease risk factors: a systematic review with meta-analysis. *BMC public health.* 2017;17(1):683-706.

10. Huang JY, Qi SJ. Childhood obesity and food intake. *World journal of pediatrics : WJP.* 2015;11(2):101-107.

11. Brown CL, Halvorson EE, Cohen GM, Lazorick S, Skelton JA. Addressing Childhood Obesity: Opportunities for Prevention. *Pediatric clinics of North America.* 2015;62(5):1241-1261.

12. Couch SC, Saelens BE, Levin L, Dart K, Falciglia G, Daniels SR. The efficacy of a clinic-based behavioral nutrition intervention emphasizing a DASH-type diet for adolescents with elevated blood pressure. *The Journal of pediatrics.* 2008;152(4):494-501.

13. Murphy A, Kist C, Gier AJ, Edwards NM, Gao Z, Siegel RM. The feasibility of high-intensity interval exercise in obese adolescents. *Clinical pediatrics.* 2015;54(1):87-90.

14. Chaplais E, Naughton G, Greene D, et al. Effects of interventions with a physical activity component on bone health in obese children and adolescents: a systematic review and meta-analysis. *Journal of bone and mineral metabolism.* 2018;36(1):12-30.

15. Martin A, Booth JN, Laird Y, Sproule J, Reilly JJ, Saunders DH. Physical activity, diet and other behavioural interventions for improving cognition and school achievement in children and adolescents with obesity or overweight. *The Cochrane database of systematic reviews.* 2018;1:1-188.

16. O'Connor EA, Evans CV, Burda BU, Walsh ES, Eder M, Lozano P. Screening for Obesity and Intervention for Weight Management in Children and Adolescents: Evidence

Report and Systematic Review for the US Preventive Services Task Force. *Jama.* 2017;317(23):2427-2444.

17. Costigan SA, Eather N, Plotnikoff RC, Taaffe DR, Lubans DR. High-intensity interval training for improving health-related fitness in adolescents: a systematic review and meta-analysis. *British journal of sports medicine.* 2015;49(19):1253-1261.

18. Garcia-Hermoso A, Cerrillo-Urbina AJ, Herrera-Valenzuela T, Cristi-Montero C, Saavedra JM, Martinez-Vizcaino V. Is high-intensity interval training more effective on improving cardiometabolic risk and aerobic capacity than other forms of exercise in overweight and obese youth? A meta-analysis. *Obesity reviews : an official journal of the International Association for the Study of Obesity.* 2016;17(6):531-540.

19. Thivel D, Masurier J, Baquet G, et al. High-intensity interval training in overweight and obese children and adolescents: systematic review and meta-analysis. *The Journal of sports medicine and physical fitness.* 2019;59(2):310-324.

20. Corte de Araujo AC, Roschel H, Picanco AR, et al. Similar health benefits of endurance and high-intensity interval training in obese children. *PloS one.* 2012;7(8):1-8.

21. Wewege M, van den Berg R, Ward RE, Keech A. The effects of high-intensity interval training vs. moderate-intensity continuous training on body composition in overweight and obese adults: a systematic review and meta-analysis. *Obesity reviews : an official journal of the International Association for the Study of Obesity.* 2017;18(6):635-646.

22. Kessler HS, Sisson SB, Short KR. The potential for high-intensity interval training to reduce cardiometabolic disease risk. *Sports medicine (Auckland, NZ).* 2012;42(6):489-509.

23. Partridge SR, McGeechan K, Bauman A, Phongsavan P, Allman-Farinelli M. Improved eating behaviours mediate weight gain prevention of young adults: moderation and mediation results of a randomised controlled trial of TXT2BFiT, mHealth program. *The international journal of behavioral nutrition and physical activity.* 2016;13:44-55.

24. Nourse SE, Olson I, Popat RA, et al. Live Video Diet and Exercise Intervention in Overweight and Obese Youth: Adherence and Cardiovascular Health. *The Journal of pediatrics.* 2015;167(3):533-539.

25. Hammersley ML, Jones RA, Okely AD. Parent-Focused Childhood and Adolescent Overweight and Obesity eHealth Interventions: A Systematic Review and Meta-Analysis. *Journal of medical Internet research.* 2016;18(7):e203.

26. Nour M, Chen J, Allman-Farinelli M. Efficacy and External Validity of Electronic and Mobile Phone-Based Interventions Promoting Vegetable Intake in Young Adults: Systematic Review and Meta-Analysis. *Journal of medical Internet research.* 2016;18(4):e58.

27. Soltani S, Shirani F, Chitsazi MJ, Salehi-Abargouei A. The effect of dietary approaches to stop hypertension (DASH) diet on weight and body composition in adults: a systematic review and meta-analysis of randomized controlled clinical trials. *Obesity reviews : an official journal of the International Association for the Study of Obesity.* 2016;17(5):442-454.

28. Appel LJ. The Effects of Dietary Factors on Blood Pressure. *Cardiology clinics.* 2017;35(2):197-212.

29. Murray M, Dordevic AL, Bonham MP. Systematic Review and Meta-Analysis: The Impact of Multicomponent Weight Management Interventions on Self-Esteem in

Overweight and Obese Adolescents. *Journal of pediatric psychology.* 2017;42(4):379-394.

30. Piercy KL, Troiano RP, Ballard RM, et al. The Physical Activity Guidelines for Americans. *Jama.* 2018;320(19):2020-2028.

31. Kebbe M, Damanhoury S, Browne N, Dyson MP, McHugh TF, Ball GDC. Barriers to and enablers of healthy lifestyle behaviours in adolescents with obesity: a scoping review and stakeholder consultation. *Obesity reviews : an official journal of the International Association for the Study of Obesity.* 2017;18(12):1439-1453.

32. Hipsky J, Kirk S. HealthWorks! Weight management program for children and adolescents. *Journal of the American Dietetic Association.* 2002;102(3 Suppl):64-67.

33. Emrich TE, Qi Y, Lou WY, L'Abbe MR. Traffic-light labels could reduce population intakes of calories, total fat, saturated fat, and sodium. *PloS one.* 2017;12(2):1-10.

34. van Biljon A, McKune AJ, DuBose KD, Kolanisi U, Semple SJ. Do Short-Term Exercise Interventions Improve Cardiometabolic Risk Factors in Children? *The Journal of pediatrics.* 2018;203:325-329.

35. Herget S, Reichardt S, Grimm A, et al. High-Intensity Interval Training for Overweight Adolescents: Program Acceptance of a Media Supported Intervention and Changes in Body Composition. *International journal of environmental research and public health.* 2016;13(11):1-13.

36. Lee S, Spector J, Reilly S. High-intensity interval training programme for obese youth (HIP4YOUTH): A pilot feasibility study. *Journal of sports sciences.* 2017;35(18):1-5.

37. Taylor KL, Weston M, Batterham AM. Evaluating intervention fidelity: an example from a high-intensity interval training study. *PloS one.* 2015;10(4):1-6.

38. Joseph RP, Dutton GR, Cherrington A, et al. Feasibility, acceptability, and characteristics associated with adherence and completion of a culturally relevant internet-enhanced physical activity pilot intervention for overweight and obese young adult African American women enrolled in college. *BMC research notes.* 2015;8:209-209.

39. Poon ET, Sheridan S, Chung AP, Wong SH. Age-specific affective responses and self-efficacy to acute high-intensity interval training and continuous exercise in insufficiently active young and middle-aged men. *Journal of exercise science and fitness.* 2018;16(3):106-111.