Live Video Diet and Exercise Intervention in Overweight Adolescents and Vascular Health

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PURPOSE

To evaluate the adherence of overweight and obese adolescents to a live-video diet and exercise intervention program and the effect of the program on measures of vascular health and traditional cardiovascular risk factors.

INTRODUCTION

Atherosclerosis and Pediatrics

- Atherosclerosis begins in childhood with the accumulation of lipids in the intima of the arterial wall[1] and is associated with traditional cardiovascular risk factors that are increasing in incidence in youth.[2]
- Adolescence is a critical window of time for atherosclerosis prevention since fatty streaks progress to permanent fibrous plaques in young adulthood.[1]

Non-invasive Measurement of Preclinical Atherosclerosis

- Validated tools exist for evaluating vascular dysfunction in youth including endothelial function testing, arterial applanation tonometry, and carotid ultrasound.

Lifestyle Interventions in Pediatrics

- Lifestyle interventions incorporating diet and exercise improve the cardiovascular risk profile of youth[3] and improve measures of vascular function.[4]
- Limited success, especially in pediatric weight management, due to high rates of attrition (27-73%)[5] and poor attendance (less than 50%).[6]
- Commonly reported barriers to participation in clinic-based programs include caregiver work hours, transportation, and having to miss school.[6]

Use of Telehealth for Health Interventions

- Live video conferencing allows in-person interventions to be delivered to hard-to-reach groups like adolescents in the comfort of their homes
- Used with success to deliver interventions to children and adolescents with diabetes, mental illness, and other chronic health conditions.[7-9]
- Live video conferencing is a growing trend in fitness training, but has not been studied as a tool to deliver live diet and exercise training to adolescents.

METHODS

Study Participants

- 20 overweight or obese youth were recruited
- *Inclusion criteria:* 1) age 10-19 years; 2) BMI > 85th percentile for age and gender; 3) computer and Internet access at home; 4) presence of adult at home during exercise for participants <14 years of age;
- *Exclusion criteria:* 1) latex allergy; 2) acute illness; 3) other medical conditions

Measures

Assessment visits were completed at baseline and after the completion of the 12-week intervention. Subjects were instructed to fast overnight prior to the appointment.

- ***Demographic and clinical data***
- ***Anthropometric data***
- ***Endothelial function:*** Endothelial Pulse Amplitude Testing (EndoPAT, Figure 1) captures a beat-to-beat plethysmographic recording of a reactive hyperemia response.
- ***Arterial applanation tonometry:*** Performed with a pressure tonometer (SphygmoCor, Figure 2).
- ***Carotid ultrasound:*** The right common carotid artery (CCA) and left CCA were examined (Figure 3) and cross-sectional diameters of the CCA in systole and diastole were measured to calculate the arterial pressure-strain elastic modulus (Ep) and stiffness index (β_{index}).
- ***Laboratory analysis:*** Fasting plasma lipid profile and C-reactive protein were measured.
- ***Functional capacity:*** Subjects underwent progressive cardiopulmonary exercise testing according to clinical protocol. Functional movement screening™ (FMS) was conducted to evaluate seven fundamental movement patterns for evidence of functional limitations and asymmetries.[10]

Figure 1: Endothelial pulse amplitude testing (EndoPAT)

Image Source: Itamar Medical, Inc.

Figure 2: Arterial applanation tonometry

Image Source: AtCor Medical, Inc.

Figure 3: Carotid ultrasound

Statistical analysis

Data are reported as mean ± standard deviation, median [range], or frequency (percent). Measurements at baseline and post-intervention were compared using paired t-test or Wilcoxon signed rank test as appropriate. P ≤ 0.05 was considered statistically significant.

INTERVENTION

Exercise Intervention

- Sessions led by trainer using Skype video conferencing software (Figure 4)
- Held 3 times per week over 12 weeks, scheduled any day of the week between 7:00AM and 9:00PM, subjects allowed to reschedule to another day in the week
- Subjects received jump rope, resistance band, and weighted medicine ball
- Aerobic and resistance training in circuit format, lasting 45-60 minutes

Adherence: If subjects attended fewer than three sessions per week, missed sessions were recorded as absences and the reason for non-attendance was recorded. Evaluated as percent of participants who completed and percent of sessions attended on schedule.

Figure 4: Exercise intervention

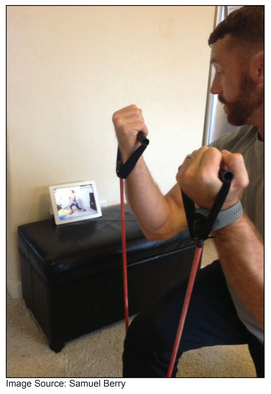

Image Source: Samuel Berry

Diet Intervention

- Employed the Dietary Approaches to Stop Hypertension (DASH) diet developed for adolescents.[11]
- Manual was provided to each participant and reviewed with a nutritionist
- Nutrition check-ins were scheduled weekly
- Food goals included: 1) keeping a detailed food records on paper for 5 of 7 days; 2) increasing intake of fruits and vegetables up to 8-9 servings per day; 3) increasing intake of low-fat dairy foods up to 3 servings per day; 4) lowering intake of foods high in fat and sodium to less than 15 per week

Adherence: Evaluated by the percentage of dietary sessions attended, achievement of the dietary goals, and change in self-reported number of servings of food groups.

RESULTS

Adherence to Exercise

- 17/20 (85%) of subjects completed the intervention
- The 20 subjects attended 90 ± 15% of scheduled sessions
- Reasons given for absences include:
  1. Illness or injury (23%)
  2. School activities or homework (21%)
  3. Scheduled holidays (18%)
  4. Forgetting the appointment (8%)
  5. Internet connectivity problems (7%)
  6. Other (7%)
  7. Unreported (16%)

Adherence to Diet

- 2/20 (10%) subjects met target for fruits and vegetables, 4/20 (20%) met target for low-fat dairy, and 17/20 (85%) met target for foods high in fat or sodium.
- Subjects reported significantly increased daily consumption of fruits and vegetables (+2.0 servings, p<0.001) and low-fat dairy (+0.64 servings, p=0.03) and reduced weekly consumption of foods high in fat or sodium (-12.6 servings, p<0.001)

Definitions of Vascular Measures

RHI: Reactive hyperemia index by EndoPAT; lower values indicate worse endothelial function

AIx: Augmentation index by applanation tonometry; larger values indicate stiffer arteries

AIx_{75bpm}: AIx adjusted to a standard heart rate

PWV: Pulse wave velocity by applanation tonometry; faster values indicate stiffer arteries

Table 1: Subject Demographics and Baseline Characteristics

Anthropometrics	
Sex (male / female)	11 (55%) / 9 (45%)
Age (years)	14.5 ± 2.1
Height (cm)	163.5 ± 10.0
Weight (kg)	81.2 ± 17.5
Body Mass Index (m²)	30.2 ± 5.0
Body Mass Index z-score	1.94 ± 0.43
Blood Pressure Profile	
Systolic BP (mm Hg)	115.5 ± 10.9
Diastolic BP (mm Hg)	69.1 ± 6.1
Mean BP (mm Hg)	80.0 ± 7.0
Blood Laboratory (mg/dL)	
Total Cholesterol	155.7 ± 27.2
Triglycerides	91.8 ± 40.2
HDL Cholesterol	47.4 ± 12.0
LDL Cholesterol	90.1 ± 20.5
C-Reactive Protein	0.3 [<0.2-1.4]
Race/Ethnicity	
White, Non-Hispanic	5 (25%)
White, Hispanic	10 (50%)
Asian	5 (25%)

Vascular Health

- Secondary analysis showed subjects with reduced vascular function showed significant change
- Cut-offs for reduced vascular function:
  - ***RHI*** ≤ 1.91[12]
  - ***PWV*** > 4.5 m/s (10-14 years); >5.5 m/s (15-19 years)[13]
  - ***AIx*** > 1% (10-14 years); >6% (15-19 years)[14]
  - ***AIx_{75bpm}*** > -2% (10-14 years); >5% (15-19 years)[14]

Table 2: Changes in Measurements Between Visits

	n	Difference Between Visits	p
Anthropometrics			
Weight (kg)	17	-0.4 [-4.9 – 13.8]	NS
Body Surface Area (m²)	17	0.0 [-1.3 – 3.1]	NS
Body Mass Index (kg/m²)	17	-0.2 [-1.3 – 3.1]	NS
Body Mass Index z-score	17	-0.03 (95% CI -0.10 – 0.03)	NS
Waist-Hip Ratio	17	**-0.03 (95% CI -0.05 – 0.00)**	**0.03**
Blood Pressure Profile			
Systolic BP (mm Hg)	17	0.18 (95% CI -4.21 – 4.56)	NS
Systolic BP percentile (%)	17	-1.29 (95% CI -13.4 – 10.8)	NS
Diastolic BP (mm Hg)	17	0.12 (95% CI -2.95 – 3.18)	NS
Diastolic BP percentile (%)	17	-0.41 (95% CI -10.2 – 9.41)	NS
Mean BP (mm Hg)	17	1.47 (95% CI -2.51 – 5.45)	NS
Vascular Measures			
RHI	17	0.16 (95% CI -0.25 – 0.57)	NS
RHI_{low}	12	**0.49 (95% CI 0.13 – 0.85)**	**0.01**
AIx (%)	17	1.35 (95% CI -4.64 – 7.35)	NS
AIx_{high} (%)	6	**-4.50 (95% CI -8.30 – -0.70)**	**0.03**
AIx_{75bpm} (%)	17	-0.88 (95% CI -7.51 – 5.75)	NS
$AIx_{75bpm\ high}$ (%)	7	**-9.00 (95% CI -17.32 – -0.68)**	**0.04**
PWV (m/s)	16	-0.10 95% CI (-0.70 – 0.48)	NS
PWV_{high} (m/s)	7	**-0.94 (95% CI -1.83 – -0.04)**	**0.04**
Ultrasound Measures			
Right CCA			
Ep (mm Hg)	17	-64.0 (95% CI -152.3 – 24.3)	NS
β_{index}	17	-0.67 (95% CI -1.59 – 0.25)	NS
Left CCA			
Ep (mm Hg)	17	-9.52 (95% CI -51.7 – 32.6)	NS
β_{index}	17	-0.11 (95% CI -0.58 – 0.35)	NS
Laboratory Analysis			
Total Cholesterol (mg/dL)	16	**-11.6 (95% CI -18.8 – -4.3)**	**0.004**
Non-HDL Cholesterol (mg/dL)	16	**-8.8 (95% CI -14.5 – -3.1)**	**0.005**
Triglycerides (mg/dL)	16	5.1 (95% CI -14.8 – 24.9)	NS
HDL Cholesterol (mg/dL)	16	-2.8 (95% CI -7.3 – 1.8)	NS
LDL Cholesterol (mg/dL)	16	**-9.9 (95% CI -16.1 – -3.6)**	**0.004**
C-Reactive Protein (mg/dL)	16	0.0 [-1.4 – 0.8]	NS
Functional Capacity			
$VO_{2\ max}$ (mL/min)	15	5.3 (95% CI -82.9 – 93.4)	NS
$VO_{2\ max/kg}$ (mL/min/kg)	15	0.0 (95% CI -1.2 – 1.2)	NS
HR_{max} (bpm)	15	**-8.9 (95% CI -13.3 – -4.6)**	**0.001**
Percent Predicted $VO_{2\ max}$ (%)	15	0.0 (95% CI -2.8 – 2.8)	NS
Percent Predicted HR_{max} (%)	15	**-4.5 (95% CI -6.6 – -2.4)**	**<0.001**
Percent Predicted $VO_{2\ pulse}$ (%)	15	**3.2 (95% CI 0.9 – 5.5)**	**0.01**
Percent Predicted AT (%)	15	0.4 (95% CI -2.2 – 3.0)	NS
Respiratory Exchange Ratio	15	-0.02 (95% CI -0.11 – 0.06)	NS
FMS Total Score	16	**3.8 (95% CI 2.5 – 5.1)**	**<0.001**

BP: Blood pressure; RHI: Reactive hyperemia index; RHI_{low}: RHI ≤ 1.91; AIx: Augmentation index; AIx_{high}: AIx > 1% (10-14 years), >6% (15-19 years); AIx_{75bpm}: AIx adjusted for standard heart rate of 75 bpm; $AIx_{75bpm\ high}$: AIx_{75bpm} > -2% (10-14 years), >5% (15-19 years); PWV: Pulse wave velocity; PWV_{high}: PWV > 4.5 m/s (10-14 years), >5.5 m/s (15-19 years); CCA: Common carotid artery; Ep: Arterial pressure-strain elastic modulus; β_{index}: Stiffness index; HDL: High density lipoprotein; LDL: Low-density lipoprotein; $VO_{2\ max}$: Peak volume of consumed oxygen; $VO_{2\ max/kg}$: $VO_{2\ max}$ divided by subject weight in kilograms; HR_{max}: Peak heart rate; $VO_{2\ pulse}$: VO_2 consumed per heart beat ($VO_{2\ max}$ / HR_{max}); AT: Anaerobic threshold; FMS: Functional movement screening

CONCLUSIONS

Adherence

- Participants showed a low attrition rate (15%) and very good adherence to exercise intervention.
- Participants showed only moderate adherence to diet intervention (10%, 20%, and 85% met targets for fruits and vegetables, low-fat dairy, and foods high in fat or sodium, respectively), but significant improvements in blood lipid profile suggest a less intensive intervention may be sufficient for changing diet in overweight adolescents.

Vascular Health

- Endothelial function was impaired in 71% of the study participants based on mean values published for a healthy, lean adolescent population[12], and arterial stiffness was impaired in 41% of participants based on median values for healthy lean adolescents.[14]
- Measures of endothelial function (RHI) and arterial stiffness (PWV, AIx, AIx_{75bpm}) improved in participants with reduced vascular function at baseline.

BMI and Body Composition

- Changes in vascular measures, blood lipids, and aerobic fitness occurred without a concurrent change in BMI.
- Significant change in waist-hip ratio indicates a change in body composition rather than reduction of weight
- Consistent with other exercise training interventions in adolescents which demonstrate that the primary effects of training are parallel reduction in body fat mass and increase in lean muscle.[15]

Aerobic Fitness

- Significant increase in $VO_{2\ pulse}$, a surrogate indicator for stroke volume since it measures volume of oxygen consumed per heart beat[16], suggests an effect of training on ventricular systolic function without a concurrent increase in $VO_{2\ max}$.

LIMITATIONS

- Subgroup analysis using baseline cut-offs was conducted post-hoc and may be vulnerable to type 1 error, requires confirmation in a controlled trial
- Self-selecting participants may be more motivated to change behavior and health, and use of incentives to promote follow-up may have artificially improved the attrition rate
- Longevity of health effects is unknown and longer studies are necessary to determine if the results can be maintained as the adolescent approaches adulthood.

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Study data were collected and managed using REDCap electronic data capture tools hosted at Stanford University.[17]

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