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The Effect of a Structured Exercise Program on Nutrition and Fitness Outcomes in Human Immunodeficiency Virus-Infected Children

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Abstract

The feasibility and effectiveness of a hospital-based exercise-training program followed by a home-based program for improving fitness, strength, and changes in body composition in children and adolescents with HIV were evaluated. Subjects participated in nonrandomized 24-session, hospital supervised exercise training program followed by an unsupervised home-based maintenance program. Outcome measurements included muscular strength/endurance, flexibility, relative peak VO_2, body composition, and lipids. Seventeen subjects (eight females) with a median age of 15.0 years (range: 6.0–22.6) and BMI z-score of 0.61 (range: −1.70–2.57) at entry completed the intervention. After 24 training sessions, the median increases in muscular strength were between 8% and 50%, depending on muscle group. The median increases in muscle endurance, relative peak VO_2, and lean body mass were 38.7% (95% CI: 12.5–94.7; $p = 0.006$), 3.0 ml/kg/min (95% CI: 1.5–6.0; $p < 0.001$), and 4.5% (95% CI: 2.4–6.6; $p < 0.001$), respectively. Twelve children completed the home-based maintenance program. Median changes in these outcomes between completion of the hospital-based intervention and a follow-up after completion of the home-based program were near zero. No adverse events occurred during the intervention. A supervised hospital-based fitness program is feasible, safe, and effective for improving general fitness and strength as well as lean body mass in children with HIV.

Introduction

Physical activity contributes to positive health outcomes for adults who participate in regular exercise programs. These include decreased rates of coronary artery disease, hypertension, obesity, diabetes, incidences of some cancers, and improved quality of life.[1] With greater recognition of sedentary behaviors of children, interest has turned toward exploring the effects of exercise in children, with the recognition that early implementation of healthy habits may have positive behavioral effects later in adulthood, when physical activity usually declines.[2,3] Previous studies have shown that active children, compared with inactive peers, have greater muscular strength, advanced motor skills, higher cardiovascular fitness,[4] and often improved disease-specific endpoints. Specific programs designed to improve strength, flexibility, and endurance in healthy children have been studied and appear to be safe in children as young as 6 years of age.[5,6]

The presence of cardiovascular risk factors (adiposity, decreased lean body mass, hyperlipidemia and insulin resistance), a result of highly active antiretroviral therapy (HAART) or chronic viral infection, is common in both HIV-infected adults and children.[7,8] Abnormal cardiovascular risk profiles may contribute to or be exacerbated by a sedentary lifestyle. The positive effects and safety of exercise training have been well documented in adults with HIV and cardiovascular risk,[9–11] with only preliminary studies noted in children.[12] As HIV has become a chronic illness, with long-term toxicities relating to the infection and its therapies, it will be important to determine if lifestyle interventions, such as structured exercise programs, are practical, safe, and effective for children with HIV. We present the results on the effects of a supervised, hospital-based exercise program followed by an

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unsupervised, home-based maintenance program for HIV-infected children. Our goal was to determine if a structured training program in HIV-infected children is feasible and safe, improves fitness and strength, and changes body composition. A secondary goal was to determine whether gains from a hospital-based exercise program can be maintained at home.

Materials and Methods

Participants

Between 2001 and 2007, HIV-infected children age 6 years or older followed at the University of Rochester Pediatric HIV and the University of Miami Pediatric Special Immunology and Adolescent Medicine Programs were invited to participate in this nonrandomized exercise intervention study. Children received medical clearance from their primary physician (e.g., no medical conditions that would be contraindicated) to participate and the children understood the training program. Informed consent was signed by parents/legal guardians and assent was signed, if applicable. This study received approval from the Human Subjects Review Office, University of Miami; Western Institutional Review Board, Olympia, WA; and Office for Human Subject Protection at the University of Rochester Medical Center, Rochester, NY.

Outcome measures

Exercise strength assessment occurred at one of three time points: at baseline, at completion (24 visits over approximately 12 weeks), and at postcompletion follow-up (approximately 3 months after completion). Other clinical and body composition outcome measures were collected over a series of visits scheduled for the study or regular clinical care and were matched as closely a possible within ± 60 days to each exercise strength assessment. The same clinician at each center performed all measures on a given patient. Subjects were familiarized with equipment during a visit prior to baseline testing.

Strength testing. Hand dynamometry assessed upper extremity strength. Testing procedures followed the recommendations of The American College of Sports Medicine (ACSM).[13] A Jamar hand dynamometer (Sammons Preston, Bolingbrook, IL) measured grip strength (lb, mean of three attempts). For other strength measurements, the subjects tested on either the pediatric equipment (Promaxima Manufacturing, Houston, TX) or the adult resistance equipment (Life Fitness, Schiller Park, IL). Maximal strength (lb) was assessed on all resistance equipment. A one repetition maximum (1-RM) measured maximal strength and was calculated using the Mayhew regression equation.[14] Subjects were allowed several warm-up repetitions on each piece of equipment. Based on clinical assessment,[15] subjects were instructed to complete as many repetitions as possible with incremental resistance until unable to complete greater than eight repetitions. For subjects ($n = 2$) who failed to complete a single repetition on the lowest weight setting for leg extensions and curls, we estimated the actual 1-RM as 5 lb, the midpoint between zero and the lowest weight setting (10 lb).

Flexibility and muscular endurance testing. A sit-and-reach test (Figure Finder, Rockton, IL) measured flexibility (cms), recording the highest value of three attempts. Muscular endurance was measured by the sit-up test (maximal number of sit-ups completed in 1 min). One subject failed to complete a single sit-up at baseline; a baseline value of 0.5 was used to calculate percent changes. Standardized procedures were used when testing, as recommended by the ACSM.[13]

Aerobic fitness testing. A maximal metabolic stress test to volitional exhaustion was completed on a motor-driven treadmill. The modified Balke protocol [constant speed 3.3 (mph) with increasing grade] was used to assess cardiorespiratory fitness [peak VO_2 (ml/min/kg)].[16] Baseline heart rate, blood pressure, and respiratory rate were measured. Rate of perceived effort (RPE) scales assessed perception of effort. The test was considered maximal if the subject could not maintain workload, if the RPE was at least 17, and if the exercise physiologist determined maximal effort had been reached. Relative peak VO_2 (ml/min/kg) was calculated using Balke's formula for treadmill testing.[16]

Anthropometrics and body composition. Body weight (kg), height (cm), waist and hip circumference (cm), and body mass index (BMI) were measured and calculated by conventional techniques.[17] Age- and sex-specific BMI z-scores were calculated from the CDC growth curves.[17] For patients >20 years, BMI z-scores were calculated based on parameters for a 20-year-old person. Body composition was measured by dual x-ray absorptiometry (DXA) (GE/Lunar Prodigy, Madison, WI; enCORE 2006 software version 10.50.086) using methods previously described.[18]

Laboratory studies. Fasting total cholesterol (mg/dl), high-density lipoprotein (HDL)-cholesterol (mg/dl), low-density lipoprotein (LDL)-cholesterol (mg/dl), triglycerides (mg/dl) and viral load (copies/ml), and CD4 counts (cells/mm^3) were measured as part of routine clinical care.

Exercise training protocol

Hospital-based program. The program was composed of 24 supervised sessions in the hospital's gym occurring approximately semiweekly. Each session lasted approximately 1.25 h and a minimum of 48 h was required between sessions. Each session consisted of warm-up and stretching (15 min), aerobic exercises (25 min), resistance training (25 min), and cool-down and stretching (10 min). Aerobic activities targeted 50–75% of the maximal heart rate. Resistive loads were set at 50% of the 1-RM. Subjects completed two sets of 10–12 repetitions in circuit format. Core strength exercises (abdominal curls) were performed at the end of every third exercise. If a subject missed a training session, it was added to the end of the program.

Home-based maintenance program. An unsupervised home-based maintenance program was prescribed for all subjects at the completion of the hospital phase. The components of the program were similar (flexibility, aerobic, and resistance), with modification of the delivery method. Whereas stretching and flexibility activities remained the same, aerobic activities were less structured. All subjects were encouraged to participate in at least 20 min of aerobic exercises at home. All subjects were given a set of dumbbells and

a resistance cord with individualized instruction. The prescribed exercises included all major muscle groups and subjects demonstrated competence prior to beginning the home-based program. Subjects were contacted several times by telephone during the home-based program.

Statistical methods

In four cases where individuals from the same biological or adoptive family enrolled in the study, one individual was randomly selected for analysis using a pseudorandom number generator. Thus, the sample used for analysis comprised 34 of the 38 children enrolled (five of six from Rochester). Nonparametric and exact statistical techniques were used. To compare baseline demographic and clinical characteristics between completers and noncompleters, we used Fisher's exact test for categorical variables and the Wilcoxon rank-sum test for continuous variables. To avoid center confounding, this comparison was done only among subjects from Miami. For the effectiveness analysis on completers, absolute or percent changes in continuous outcomes were calculated within individuals from baseline to completion and from completion to postcompletion follow-up. The Hodges–Lehmann estimate of the median within-individual change and the exact 95% confidence interval associated with the sign test were calculated. The sign test was used to obtain an exact two-sided p-value under the null hypothesis that the median within-individual absolute or percentage change from baseline to completion was zero. For dichotomous outcomes, the exact conditional logistic regression estimate of the within-individual change in the odds of the outcome, expressed as an odds ratio, and its exact 95% confidence interval were calculated.[19] This technique was also used to obtain an exact two-sided p-value from the exact conditional scores test under the null hypothesis that the within-individual odds ratio was equal to 1 between baseline and completion. p-values were not calculated for the changes in continuous or dichotomous outcomes between completion and postcompletion follow-up as the null hypothesis of no change is inappropriate for assessing equivalence and p-values for the appropriate null hypothesis would depend on an arbitrarily chosen range of equivalence.[20]

Certain constructs such as upper body strength were measured by multiple outcomes. To limit the chances of a false finding of effectiveness or confidence interval coverage less than the stated level for a given construct while still reporting on a variety of measures, joint inference was performed across all outcomes that were measures of a single construct using the Bonferroni correction. All analyses were performed using SAS/STAT software, Version 9.1.3 of the SAS System for Windows (SAS Institute Inc., Cary, NC).

Results

Baseline clinical characteristics

Among the 34 participants (five from Rochester) analyzed, 17 (four from Rochester) completed the hospital-based intervention in a median of 16 weeks (range: 10–19 weeks). There were 17 noncompleters (1 from Rochester) with 11/17 completing only baseline or <4 weeks of training. Table 1 shows baseline demographic and clinical characteristics for all completers and compares completers and noncompleters at Miami. Completers at Miami were slightly younger and had less advanced CDC stages, lower CD4%, and BMI z-scores closer to normal at baseline than noncompleters, although these differences could be due to randomness alone ($p \geq 0.16$ for each variable). The reasons for noncompletion given by the participants, when known, were not related to health or the intervention but rather logistical factors such as incompatible school or work schedules.

Effect of the hospital-based exercise intervention

Table 2 shows the number of observations and summary statistics for baseline values of outcome measures in all completers and also describes the within-individual absolute or percentage changes from baseline, as appropriate for the outcome. Overall, the greatest changes were noted in strength. On average, upper and lower extremity strength improved ($p < 0.001$) with gains across nearly all muscle groups. Muscular endurance ($p = 0.006$), flexibility ($p < 0.001$), and cardiorespiratory fitness measured by peak relative VO_2 ($p < 0.001$) also showed substantial improvement. Total lean body mass increased from baseline ($p < 0.001$). Median changes in trunk adiposity and lipid profiles were close to zero, though the 95% CIs did not allow us to rule out the possibility of large positive or negative changes in these outcomes. The median change in CD4% was zero, and the lower limit of the 95% CI allowed us to rule out a decline in CD4% of more than 1% between baseline and completion. The odds of a subject having viral load at or below 10,000 copies/ml at completion were twice those at baseline, though the 95% CI did not allow us to rule out larger increases or large reductions.

Effect of the home-based maintenance program

Twelve (71%) of the children who completed the exercise program returned for a follow-up assessment after a median of 17 weeks (range: 13–34 weeks), during which time they were instructed to follow the home-based program. Changes in exercise-related outcomes between completion and postcompletion follow-up are shown in Table 3. The estimated median changes, which were generally near zero, provided some evidence that strength, endurance, aerobic capacity, and total lean mass gains may have been maintained, but the 95% CIs did not allow us to rule out further improvement or reversal of the gains in these outcomes. However, flexibility declined between completion and follow-up based on the 95% CI.

Discussion

In this pilot and feasibility study, we demonstrate that a supervised hospital-based exercise rehabilitation program for HIV-infected children, adolescents, and young adults is feasible and for those patients who voluntarily completed the exercise program, we found a strong positive relationship between the intervention and strength, flexibility, cardiorespiratory fitness, and lean body mass. In a subgroup of the participants who returned for a follow-up assessment after approximately 3 months of an unsupervised, home-based maintenance program, the estimated median changes suggest that the child in this subgroup maintained most of the gains, though further research is needed to confirm these findings.

Table 1. Baseline Demographic and Clinical Characteristics of 33 HIV$^+$ Children Who Enrolled in a Supervised, Hospital-Based Exercise Intervention, by Completion Status

Characteristic	*All completers* (N = *17*)	*Miami completers* (N = *13*)	*Miami noncompleters* (N = *16*)	p[a]
	N/*total (%) or median (minimum, maximum)*			
Age (years)	15.0 (6.0, 22.6)	15.9 (6.0, 22.6)	17.6 (10.8, 23.0)	0.68
Female	8/17 (47)	5/13 (38)	7/16 (44)	1.00
Race				1.00
Black, non-Hispanic	11/17 (65)	9/13 (69)	10/16 (63)	—
Hispanic	4/17 (24)	3/13 (23)	4/16 (25)	—
White, non-Hispanic	2/17 (12)	1/13 (8)	1/16 (6)	—
Other, non-Hispanic	0/17 (0)	0/13 (0)	1/16 (6)	—
CDC stage				0.16
N (1–3)	2/17 (12)	2/13 (15)	0/10 (0)	—
A (1–3)	4/17 (24)	4/13 (31)	1/10 (10)	—
B (1–3)	5/17 (29)	2/13 (15)	6/10 (60)	—
C (1–3)	6/17 (35)	5/13 (38)	3/10 (30)	—
Route of infection				0.65
Vertical	14/17 (82)	10/13 (77)	11/15 (73)	—
Antiretroviral medications				—
NRTI	16/17 (94)	12/13 (92)	12/16 (75)	0.34
NNRTI	3/17 (18)	2/13 (15)	1/16 (6)	0.57
PI	13/17 (76)	10/13 (77)	10/16 (63)	0.45
CD4 (%)[b]	25.0 (0.0, 44.0)	26.0 (0.0, 44.0)	31.0 (14.0, 38.0)	0.71
Viral load ≤10,000 copies/ml	9/15 (60)	7/11 (64)	7/12 (58)	1.00
BMI z-score[c]	0.61 (−1.70, 2.57)	0.61 (−1.01, 2.57)	1.57 (−1.48, 2.14)	0.50
Reason for noncompletion				—
Moved out of area	—	—	1/16 (6)	—
Interfered with school schedule	—	—	4/16 (25)	—
Lack of transportation	—	—	2/16 (13)	—
Began work	—	—	5/16 (31)	—
Unknown	—	—	4/16 (25)	—

[a]Exact *p*-value for the test of the null hypothesis of no difference in the distributions of the variable of interest in completers and noncompleters in the Miami cohort using Fisher's exact test for categorical variables and the Wilcoxon rank-sum test for continuous variables.
[b]$N = 15$ for all completers, $N = 12$ for completers in Miami, and $N = 12$ for noncompleters in Miami.
[c]$N = 12$ for noncompleters in Miami.

With the more widespread use of highly active antiretroviral therapies (HAART), HIV-infected children have a greater life expectancy, yet many have developed cardiovascular risks such as increased overall adiposity, centralized adiposity, lean body mass wasting, hyperlipidemia, and insulin resistance.[8,21] These cardiovascular risks have been attributed to antiretroviral therapies and/or HIV alone.[7] The extent to which cardiovascular risk profiles will impact short- and long-term cardiovascular morbidity and mortality is unknown in HIV-infected children. However, evidence gleaned from HIV-infected adults shows them to have an increased risk of cardiovascular events.[22] Thus, recognizing these risk factors and instituting early interventions may be one of the most effective approaches.

Physical activity decreases cardiovascular risk either before or after a cardiovascular event in adults.[23] Less is known about the effectiveness and safety of this intervention in children. Global increases in overweight, obesity, and other chronic illnesses among children and adolescents have underscored the urgent need for effective physical activity programs. Children with chronic illness are likely to have decreased physical activity, muscle strength, aerobic capacity, and overall deconditioning that may contribute to their overall morbidity.[24] Physical inactivity is associated with increases in body fat and abnormal metabolic factors—problems that are already faced by HIV-infected children. Regular physical activity has the potential to offset these modifiable risk factors.

Although all of our participants were outpatients and generally well, many were deconditioned at baseline (because of a low peak VO_2), similar to another report.[25] However, aerobic capacity increased significantly after completion of the hospital-based program. Furthermore, strength increased in most muscle groups. Improved strength can be due to muscle hypertrophy in postpubertal children, yet this plays less of a role in the prepubertal child who has lower anabolic sex hormones. Greater neuronal activity or neural units could account for the increased strength in the prepubertal child.[26] The overall positive effects of exercise on strength and aerobic conditioning in the HIV-infected child may allow for greater functional capabilities, quality of life, and added physical activity outside the structured exercise program, similar to some studies in HIV-infected adults.[27]

Lean body mass increased between baseline and completion. Lean body mass can help regulate glucose metabolism by improving insulin sensitivity. Exercise can also improve other metabolic endpoints.[28] In adults with HIV, exercise programs have resulted in conflicting effects on these

Table 2. Baseline Values and Changes between the Baseline and the Completion Assessments in Exercise-Related and Clinical Outcome Measures

Outcome	N	*Baseline median (min, max) or proportion*	*Median change or odds ratio (95% CI)*[a]	p[b]
Upper body strength (lb, % chg)				**<0.001**
Chest press 1-RM[c]	17	65 (13, 141)	29.0 (8.2, 46.8)	**0.02**
Lat pulldown 1-RM	17	110 (37, 158)	24.1 (0.00, 40.2)	0.06
Shoulder press 1-RM	17	48 (13, 95)	20.0 (0.0, 55.3)	**0.03**
Pec dec 1-RM	16	81 (11, 167)	25.0 (16.4, 72.1)	**0.004**
Tricep extension 1-RM	17	38 (12, 68)	27.7 (10.5, 54.1)	**0.004**
Bicep curl 1-RM	16	59 (5, 124)	34.8 (13.3, 54.6)	**<0.001**
R hand grip mean 1-RM	17	57 (13, 112)	8.1 (1.2, 29.6)	**0.002**
L hand grip mean 1-RM	16	52 (9, 112)	11.3 (1.9, 27.8)	**0.03**
Lower body strength (lb, % chg)				**<0.001**
Leg press 1-RM	16	94 (23, 236)	35.9 (12.1, 128.6)	**<0.001**
Leg extension 1-RM	17	90 (5, 176)	31.4 (17.8, 100.0)	**<0.001**
Leg curl 1-RM	16	56 (5, 115)	49.5 (27.6, 103.9)	**<0.001**
No. of sit ups[d] (*N*/min, % chg)	13	31 (0.5, 42)	38.7 (12.5, 94.7)	**0.006**
Sit and reach (cm, % chg)	17	26.0 (9.5, 39.5)	15.0 (7.0, 31.9)	**<0.001**
Peak VO_2 (ml/min/kg)	16	24.0 (12.7, 38.3)	3.0 (1.5, 6.0)	**<0.001**
Overall adiposity				0.66
BMI *z*-score (SD, SDs toward zero)	17	0.61 (−1.70, 2.57)	−0.04 (−0.27, 0.07)	0.66
DXA[e] total body % fat	16	28.5 (5.9, 45.3)	−0.3 (−2.6, 1.9)	1.00
Fat centrality				1.00
DXA trunk % fat	16	30.9 (5.1, 50.5)	−0.8 (−3.9, 3.9)	1.00
DXA trunk fat % of total fat mass	16	41.2 (21.4, 78.6)	−0.2 (−3.1, 3.6)	1.00
Waist circumference (cm, % change)	15	84.4 (49.0, 108.0)	0.0 (−4.0, 5.4)	1.00
Waist/hip ratio	15	0.85 (0.67, 1.02)	0.00 (−0.03, 0.05)	1.00
DXA total lean mass (kg, % change)	16	41.2 (15.0, 52.6)	4.5 (2.4, 6.6)	**<0.001**
CD4 (%)	11	25.0 (0.0, 44.0)	0.0 (−1.0, 5.0)	1.00
Viral load ≤10,000 copies/ml[f]	10	0.60	2.00 (0.10, 117.99)	1.00
Triglycerides (mg/dl)	10	85 (56, 205)	−15 (−81, 13)	0.34
Total cholesterol (mg/dl)	10	140 (103, 188)	−1 (−16, 79)	1.00
HDL/LDL ratio	9	0.59 (0.33, 0.91)	0.02 (−0.06, 0.07)	0.29

[a]Hodges–Lehmann estimate and exact 95% CI associated with the sign test for continuous outcomes or odds ratio and 95% CI from exact conditional logistic regression for dichotomous outcomes. Confidence intervals for individual measures were Bonferroni adjusted within each multi-measure construct.

[b]*p* Values refer to the test of no change in outcomes. The exact sign test was used for continuous outcomes and for dichotomous outcomes, exact conditional logistic regression was used. *p* Values for individual measures were Bonferroni adjusted within each multi-measure construct. The *p* value reported for a multi-measure construct is the minimum of the Bonferroni-adjusted *p* values for its constituent measures.

[c]1-RM, 1 repetition maximum weight.

[d]Actual minimum of zero replaced by 0.5 so that percentage changes could be calculated.

[e]DXA, dual x-ray absorptiometry.

[f]Proportion or odds ratio.

parameters.[29,30] Insulin-sensitizing agents plus exercise appears to produce better effects than medication alone.[30] In our study, only a subset of children had metabolic laboratories [lipids and glucose/insulin (data not shown)] and we found nonsignificant changes in these profiles between baseline and completion. However, few children had abnormal metabolic profiles at the start, thus we had limited opportunity to appreciate changes over the study interval. Increasing lean body mass can potentially result in greater protection against metabolic complications associated with the disease and its treatments as HIV-infected children age.

Although the nutritional problems facing HIV-infected children in developed nations predominantly center on adverse metabolic outcomes and even obesity, some children continue to experience wasting and immunologic deterioration. Early studies on the effect of exercise programs for HIV-infected adults focused on using exercise to reverse muscle wasting or the "AIDS wasting syndrome."[31] In our study we found that exercise training did not compromise immune status and increased lean body mass. We defined positive changes in BMI *z*-score as movement toward 0 (i.e., children tracking toward being less overweight or underweight). The extent to which exercise can delay the progression of HIV remains to be seen, but early indicators in adults suggest these programs are of benefit, especially in improving functional and psychological status.[27]

Although this was a pilot and feasibility study, limitations should be considered. Our study did not have a control group of HIV-infected children who did not complete the intervention. Although this is extremely important, it is reassuring that large gains in strength, lean body mass, and aerobic capacity were detected. However, a randomized controlled trial is clearly warranted. The cardiorespiratory fitness test was measured indirectly with a prediction equation. However, this method has been validated for the clinical setting.[32] The positive findings of our study are based on the children who completed the program. The rate of attrition in our study (approximately 50%) closely parallels attrition (33–73%

Table 3. Changes in Exercise-Related Outcome Measures in 12 HIV$^+$ Children between the Completion and the Postcompletion Follow-up Assessments

Outcome	N	*(min, max)*	*Median (95% CI)*[a]
Upper body strength (lb, % change)			
Chest press 1-RM[b]	12	(−13.1, 33.3)	−0.6 (−13.1, 33.3)
Lat pulldown 1-RM	12	(−31.7, 19.9)	−1.9 (−31.7, 19.9)
Shoulder press 1-RM	12	(−31.6, 12.5)	2.2 (−31.6, 12.5)
Pec dec 1-RM	12	(−22.2, 28.0)	−2.7 (−22.2, 28.0)
Tricep extension 1-RM	12	(−43.2, 16.7)	−1.8 (−43.2, 16.7)
Bicep curl 1-RM	12	(−25.9, 36.9)	0.0 (−25.9, 36.9)
R hand grip mean 1-RM	12	(−22.3, 19.3)	−1.0 (−22.3, 19.3)
L hand grip mean 1-RM	12	(−12.2, 15.9)	0.6 (−12.2, 15.9)
Lower body strength (lb, % change)			
Leg press 1-RM	12	(−30.3, 50.0)	0.0 (−13.4, 27.1)
Leg extension 1-RM	12	(−32.4, 35.0)	9.1 (−7.3, 27.9)
Leg curl 1-RM	12	(−21.7, 16.7)	0.3 (−20.1, 14.3)
Number of sit ups	10	(−33.3, 28.2)	−5.8 (−20.7, 11.1)
Sit and reach	12	(−23.3, 5.3)	−11.5 (−19.2, −2.6)
Peak VO_2 (ml/min/kg)	12	(−4.5, 3.0)	−1.4 (−3.1, 3.0)
Overall adiposity			
BMI *z*-score (SDs toward zero)	10	(−0.25, 0.51)	0.11 (−0.24, 0.32)
DXA[c] total % fat	8	(−2.4, 4.3)	1.2 (−2.4, 4.3)
Fat centrality			
DXA trunk % fat	8	(−3.6, 9.0)	1.2 (−3.6, 9.0)
DXA trunk fat % of total fat mass	8	(−7.4, 13.4)	−0.1 (−7.4, 13.4)
Waist circumference (% change)	7	(−1.2, 14.9)	0.8 (−1.2, 14.9)
Waist/hip ratio	7	(−0.05, 0.09)	0.03 (−0.05, 0.09)
DXA total lean mass (% change)	8	(−7.1, 4.1)	1.1 (−7.1, 4.1)

[a]Hodges-Lehmann estimate and exact 95% CI associated with the sign test. Confidence intervals for individual measures were Bonferroni adjusted within each multi-measure construct. No exact sign test *p*-value is presented as the null hypothesis of no change is inappropriate for judging equivalence.
[b]1-RM, 1 repetition maximum weight.
[c]DXA, dual x-ray absorptiometry.

attrition rates) in similar studies with other cohorts.[13,33–36] Although this might limit generalizability to mandatory interventions such as school-based physical education programs, it does not reduce our ability to generalize to interventions as they would be delivered in clinical or community-based settings for HIV. Finally, we had limited ability to determine the effects of an unsupervised home-based maintenance program because of additional attrition that could also introduce the possibility of selection bias. In the future, response-increasing techniques, such as home visits, might be necessary. Future studies should analyze the effect of home-based programs as the sole mode of delivery.

HIV-infected children are now carrying cardiovascular risks forward as they move into adulthood. This is one of the first studies to show that exercise interventions in HIV-infected children are feasible and in a preliminary way, effective in improving some important factors (aerobic capacity, lean body mass) that can eventually contribute to cardiovascular risk. Safety and sustainability of an exercise intervention program for children have limited the implementation of such programs in the past. The safety and effectiveness of this program suggest that future studies should more extensively evaluate ways to increase program compliance and determine the metabolic response to exercise in children with defined cardiovascular risks and metabolic abnormalities. The sustainability of this program as the child transitions to the community will more accurately predict long-term benefits and reach larger populations of children.

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Author Disclosure Statement

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