The Effects of Exercise Training on Metabolic and Morphological Outcomes for People Living With HIV: A Systematic Review of Randomised Controlled Trials

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Purpose: To determine the effects of exercise on metabolic and morphological outcomes among people with HIV using a systematic search strategy of randomized, controlled trials (RCTs). **Methods:** Two independent reviewers assessed studies using a predetermined protocol. **Results:** Nine RCTs (469 participants, 41% females) of moderate quality were included. Compared to nonexercising controls, aerobic exercise (AE) resulted in decreased body mass index (weighted mean difference [WMD] −1.31; 95% CI, −2.59, −0.03; n=186), triceps skinfold thickness of subcutaneous fat (WMD −1.83 mm; 95% CI,−2.36, −1.30; n=144), total body fat (%) (standardised mean difference [SMD],−0.37; 95% CI, −0.74, −0.01; n=118), waist circumference (SMD −0.74 mm, 95% CI, −1.08, −0.39; n=142), and waist:hip ratio (SMD −0.94; 95% CI, −1.30, −0.58; n=142). Progressive resistive exercise (PRE) resulted in increased body weight (5.09 kg; 95% CI, 2.13, 8.05; n=46) and arm and thigh girth (SMD 1.08 cm; 95% CI, 0.35, 1.82; n=46). Few studies examined blood lipids, glucose, and bone density. **Conclusions:** Few RCTs exist and their quality varies. AE decreases adiposity and may improve certain lipid subsets. PRE increases body weight and limb girth. No additional effects of combining AE and PRE are evident. Larger, higher quality trials are needed to understand the effects of exercise on metabolic outcomes (eg, lipids, glucose, bone density) relevant to persons with chronic, treated HIV. **Key words:** *aerobic exercise, HIV, progressive resistive exercise, randomised controlled trial*

The introduction of highly active antiretroviral therapy (HAART) has reduced the morbidity and mortality associated with human immunodeficiency virus (HIV).[1,2] Even among patients with access to HAART, however, HIV remains a serious illness. In particular, both HIV infection and HAART can be associated with metabolic and morphologic complications.[3] Abnormal lipid and glucose metabolism and fat redistribution (central lipohypertrophy and peripheral lipoatrophy) are common amongst HAART-treated patients.[4,5] Osteoporosis and osteopenia are also increased.[6] These problems may predispose patients to premature cardiovascular disease, diabetes, and fractures and may increase psychological distress.

Medications may ameliorate some HAART-related problems, but their use is associated with financial costs and potential toxicities. HAART modification may improve lipoatrophy, however no drug is proven to prevent or reverse visceral lipohypertrophy.[7,8] Safe, effective, nonpharmacological interventions are needed to prevent and manage the metabolic and morphologic abnormalities seen in HIV-infected patients. Exercise training improves and maintains health and reduces chronic disease risk in healthy adults.[9] Current guidelines generally recommend nondrug therapies, including exercise and diet, as a first-line treatment for dyslipidemia in HIV,[10] based largely on the known cardiovascular benefits of exercise in other contexts. However,

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although systematic reviews have concluded aerobic exercise (AE) and progressive resistive exercise (PRE) interventions are beneficial and safe for individuals living with HIV, evaluation of morphologic endpoints was limited and metabolic parameters were not examined.[11,12]

This review was undertaken to examine the quality and content of existing clinical trial evidence of the effects of exercise training on metabolic and morphological endpoints in HIV-infected adults.

METHODS

Criteria for Considering Studies for Review

Study designs

A systematic review of the published literature was conducted on the effects of exercise training on metabolic and morphological complications in HIV-infected patients. Only randomised trials where a prescribed AE, PRE, or a combined AE and PRE intervention was compared with no exercise or with another exercise intervention at least twice weekly, over at least 4 weeks, were included. Trials combining exercise with nonexercise intervention (eg, anabolic steroids), non-English language publications, unpublished studies, abstracts, and conference proceedings were excluded.

Types of participants

Studies of HIV-infected adults (aged ≥18 years) were included.

Types of intervention

Exercise training including AE, PRE, or a combination of both, either supervised or unsupervised, were included. AE was defined as an intervention containing AE (eg, walking, jogging, running, rowing, or cycling). PRE was defined as resistive exercise intervention (eg, weight training, isotonic, or isometric exercises). Comparisons examined were exercise training versus no exercise training (control) and exercise training versus another form of exercise training.

Outcome Measures

Metabolic outcomes considered were blood lipids (total cholesterol [TC], high-density lipoprotein cholesterol [HDL], low-density lipoprotein cholesterol [LDL] and triglycerides [TG]) and blood glucose.

Morphological outcomes considered were body weight, body mass index (BMI), waist circumference, waist to hip ratio (WHR), bone mineral density (BMD), skinfold thickness of subcutaneous fat (SFT), girth circumference (chest, arm, leg), and magnetic resonance imaging (MRI) or computed tomography (CT) measured subcutaneous abdominal adipose tissue (SAT) and visceral abdominal adipose tissue (VAT).

Search Methods for Identification of Studies

Electronic searches were conducted from 1980 to November 2009 using MEDLINE, CINAHL, EMBASE, Cochrane Central Register of Controlled Trials (CENTRAL), Cochrane Database of Systematic Reviews, Physiotherapy Evidence Database (PEDro), SportDiscus, and Informit. The search combined 3 subject groups: HIV, exercise, and study design. The HIV group included the terms HIV, HIV infections, HIV long-term survivors, AIDS, human immunodeficiency virus, or acquired immunodeficiency syndrome. The exercise group included the terms exercise, physical fitness, exertion, sports, physical education and training, aerobic, anaerobic, progressive resistive/resistance, exercise therapy, or physical training.

The study design group included the terms "randomized controlled trials," "double blind," "single blind," or "clinical trials." For some databases, the search strategy was slightly modified.

The reference lists of identified manuscripts were hand-searched for additional studies that met the inclusion criteria.

Assessment of Quality

The quality of included studies was assessed using the PEDro scale, designed to assess trials of physiotherapy interventions. Criteria and scoring of the PEDro scale are described elsewhere.[13]

Data Extraction and Analyses

Two reviewers (S.F. and A.H.) independently assessed all titles and abstracts of identified studies. Full-text versions were obtained of studies where:

- participants were HIV-infected adults, and
- the intervention was AE, PRE, or combined AE and PRE performed at least twice weekly for at least 4 weeks, and
- the study was a randomised controlled trial, and
- the comparison group was either a no-exercise or another type of exercise group.

For any study where it was unclear whether these criteria were met, a discussion between the reviewers occurred to reach consensus.

Data were independently extracted from all included studies using a prepared checklist before entering into Review Manager (RevMan [Computer program], Version 5.0. Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration, 2008), with random checks for accuracy. Disagreements were resolved by discussion to reach consensus. Corresponding authors of included studies with missing data were contacted to obtain missing data where possible.

For continuous variables, the mean change from baseline or the postintervention mean and standard deviation (*SD*) for each group was recorded. The mean difference (MD) for outcomes measured with the same metric units or standardised mean difference (SMD) for outcomes measured with different metric units with 95% confidence intervals (95% CI) was calculated where possible using RevMan 5. Effect sizes and 95% confidence intervals were calculated where possible using Web-based software (www.cemcentre.org/renderpage.asp?linkid=30325017).

RESULTS

The initial search identified 2,202 citations (**Figure 1**). This was reduced to 23 studies after elimination of duplicates and application of the inclusion and exclusion criteria by 2 independent reviewers screening the title and abstracts. A further 11 studies were excluded after retrieving the full text. Of these, 8 were RCTs that did not examine outcomes of interest to this review[14–21] and 4 studies were not RCTs.[22–25] Three additional papers were excluded as they were deemed duplicate studies of included papers.[26–28] The final yield included 9 studies (**Table 1**).[29–37]

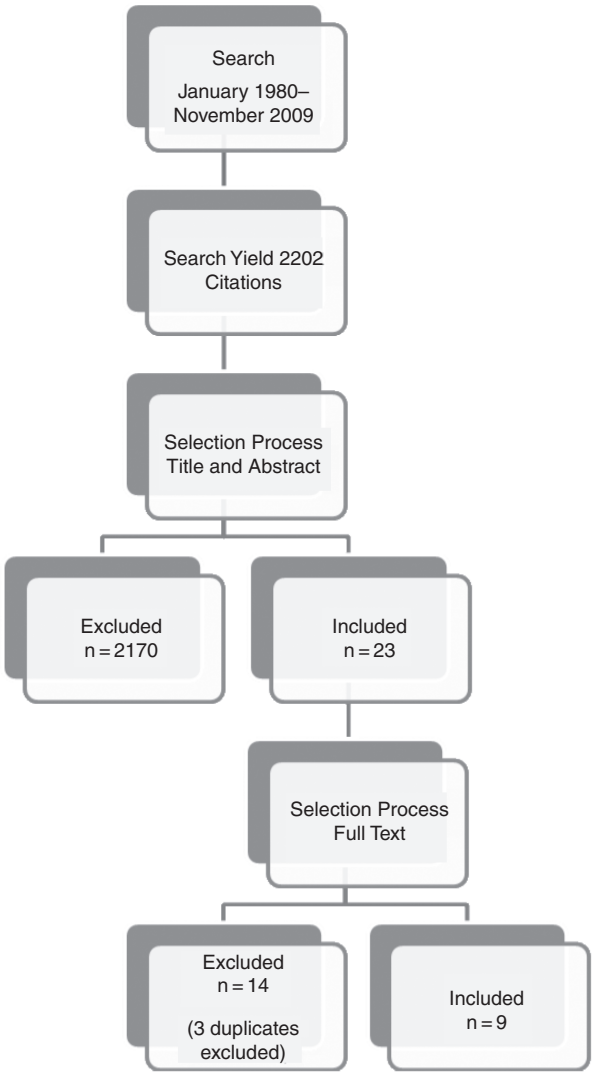

Figure 1. Search yield.

Methodological Quality

Quality of included trials as assessed by the PEDro score was a median 5 (range, 3 to 8) out of a possible score of 10. Only 1 study had concealed allocation[29] and only 2 presented an intention-to-treat analysis.[29–30] Lack of blinding was common, with only 2 studies blinding assessors.[29,31] Blinding of therapists providing the exercise intervention was not possible in any study.

Participants of Included Studies

Overall, 494 participants (41% female) were included (**Table 1**). Adults at various stages of HIV disease were included with CD4 counts ranging from <100 to >1000 cells/mm^3. The mean age of participants in individual studies ranged from 18 to 71 years. Five studies included participants who were all on HAART (at least 3 antiretrovirals),[29–33] and one did not describe antiretroviral use.[37]

The remainder recruited participants using non-HAART regimens.[34–36]

Outcomes of Included Studies

Basic anthropometric outcomes were evaluated in all included studies, however only 2 utilized imaging to assess body fat distribution[30,32] and none collected bone outcomes.

Effects of AE on Metabolic Outcomes

Two studies examined the effects of AE on blood lipids and glucose,[33,37] however insufficient data

Table 1. Characteristics of included studies in the systematic review.

Author/year/country	Number/males %	Trial design	Type of exercise	Exercise dosage: frequency, intensity, duration	Setting/supervision	Withdrawal rates
Spence et al/1990/USA	N=24/100%	2 groups: PRE and controls	Hydraulic strength training	PRE: Begin at 1 set of 15 reps at min resistance to 3 sets of 10 reps at max resistance (levels 1–6). 3/wk for 6 wks Controls: usual activity	NR/yes	0% (0/24)
Terry/1999/USA	N=31/66.7%	2 groups: moderate and high intensity interval AE	Walking/running	Moderate: 55–60% HR max 30 min (5 min target intensity, 1 min recovery) High: 75–85% HR max 30 min (5 min target intensity, 1 min recovery) Both groups: 3/wk for 12 wks and 15 min stretch pre/post	NR/yes	32% (10/31)
Perna et al/1999/USA	N=43/86%	2 groups: AE interval and control	Stationary bike	AE: 70–80% HR max; 10 min stretch pre/post; 3/wk for 12 wks Control: wait-listed control	Laboratory/yes	51% (22/43)
Smith et al/2001/USA	N=60/87%	2 groups: AE and control	Walk/jog/run treadmill or track	AE: Initial 20 min 60–80% VO_2max; warm/cool down; 3/wk for 12 wks Control: wait-listed control	Medical centre/yes	18% (11/60)
Lox et al/1996, 1995/USA	N=34/100%	3 groups: AE, PRE and control	Stationary bike, variable isotonic equipment	AE: 24 min target HR (50%–80% of HR reserve) RE: 3 × 10 reps; beginning @ 60% 1-RM Both groups: 3/wk for 12 wks	Fitness club/yes	3% (1/34)

(Continued)

Table 1. *Continued*

Author/year/ country	Number/ males %	Trial design	Type of exercise	Exercise dosage: frequency, intensity, duration	Setting/ supervision	Withdrawal rates
Dolan et al/ 2006/USA	N=40/0%	2 groups: combined AE/PRE and control	Stationary cycling, flexion-extension bench, squat stand, free weight sets	AE: 1–2 wks 20 min 60% max HR, then 30 min 75% max HR RE: 1–2 wks 60% 1RM, 2–4 wks 70% 1-RM, 5–16 wks 80% 1-RM. Warm up/cool down. 3/wk for 16 wks Control: Usual activity	Domiciliary/ yes	5% (2/40)
Fillipas et al/ 2006/ Australia	N=40/100%	2 groups: combined AE/PRE and control	Cycling, treadmill stepper or cross trainer; free weights; isotonic machines	AE: 60%–75% max HR RE: 3 sets of 10 60%–80% 1-RM; 2/wk for 24 wks Control: Walking 2/wk, 20 min and monthly group forum	Fitness club or hospital physiotherapy department/ yes	13% (5/40)
Mutimura et al/2008/ Africa	N=100/ HIV+ with LDS n=50; HIV+ without LDS n=50; HIV-40%	4 groups: AE and 3 comparison groups a. HIV+/LDS no exercise b. HIV +/no LDS no exercise c. HIV- no exercise	Walking, jogging, running, stair climbing, low back/ abdominal	AE: 1–3 wks 45–60 min 45% max HR, 4–9 wks 60% max HR, 10–24 wks 75% max HR; stretching; 15 min brisk walk 3/wk for 24 wks Control: Usual activity	Fitness club/yes	7% (13/200)
Lindegaard et al/2008/ Denmark	N=35 (20 HIV+ and 15 age- matched controls)/100%	2 groups: AE and PRE	Isotonic machines	AE: First 8 wks, mean intensity 65% VO_2max and last 8 wks, 75% VO_2max PRE: Resistance progressed gradually Both groups: 3/wk for 16 wks; 5 min warm up	Fitness club/yes	10% (2/20)

Note: NR = not reported; VO_{2max} = maximum oxygen uptake; HR_{max} = heart rate maximum; $HR_{reserve}$ = heart rate reserve; 1-RM = 1 repetition maximum.

Table 2. Effects of aerobic exercise versus no exercise controls

Outcomes	Study	Treatment group	Control group	Effect size (95% CI)
Body weight, kg	Smith et al, 2001	82.40±12.90	85.1±12.40	0.21 (–0.80, 0.38)
BMI, kg/m^2	Smith et al, 2001	26.00±4.40	27.7±4	–0.41 (–1.00, 0.19)
	Perna et al, 1999	23.5±3.2	26.9±5.9	–0.73 (–1.58, 0.18)
	Mutimura et al, 2008	–0.53±1.20	0.06±0.60	–0.62 (–1.03, –0.21)[a]
Triceps SFT, mm	Smith et al, 2001	–2.20±2.10	1.20±0.70	–2.42 (–3.14, –1.62)[a]
	Mutimura et al, 2008	–1.42±2.10	–0.20±0.70	–0.78 (–1.19, –0.36)[a]
Biceps SFT, mm	Mutimura et al, 2008	–0.63±1.6	–0.06±0.3	–0.50 (–0.90, –0.09)[a]
Central SFT, mm	Smith et al, 2001	29.8±19.0	54.1±33.4	–0.86 (–1.47, –0.22)
Peripheral SFT, mm	Smith et al, 2001	49.2±24.70	74.9±29.1	–0.94 (–1.55, –0.29)
Subscapular SFT, mm	Mutimura et al, 2008	–1.9±3.2	–0.55±1.7	–0.53 (–0.93, –0.12)[a]
Suprascapular SFT, mm	Mutimura et al, 2008	–2.1±3.5	–0.43±1.4	–0.63 (1.03, –0.22)[a]
SSF, mm	Mutimura et al, 2008	–6.15±8.2	–0.43±–1.4	–0.78 (–1.19, –0.36)[a]
Body fat, %	Mutimura et al, 2008	–1.5±3.3	–0.16±0.70	–0.56 (–0.97, –0.15)[a]
WHR	Smith et al, 2001	0.96±0.06	0.97±0.07	–0.15 (–0.74, 0.44)
	Mutimura et al 2008	–0.10±0.1	0.00±0.1	–1.00 (–1.41, –0.57)
Waist, cm	Smith et al, 2001	–2.60±2.62	0.30±4.36	–0.76 (–1.36, –0.14)
Body weight, kg	Mutimura et al, 2008	–7.13±4.4	0.03±0.7	–0.87 (–1.28, –0.45)
TC, mmol/L	Mutimura et al, 2008	–0.03±1.11	0.066±1.28	–0.08 (–0.48, 0.32)[a]
HDL, mmol/L	Mutimura et al, 2008	0.03±0.21	0.07±0.14	–0.22 (–0.62, 0.18)[a]
LDL, mmol/L	Mutimura et al, 2008	0.14±0.89	0.19±0.98	–0.05 (–0.45, 0.35)[a]
TG, mmol/L	Mutimura et al, 2008	–0.22±0.48	0.07±0.49	–0.60 (–1.00, –0.19)[a]
Glucose, mmol/L	Mutimura et al 2008	–0.21±0.71	0.39±1.25	–0.59 (–0.99, –0.18)[a]
Insulin, ρmol/L	Mutimura et al 2008	–1±18	0±0.1	–0.19 (–0.59, 0.21)

Note: Postintervention data or change score data (indicated with a superscript a) used to calculate effect sizes. Data expressed as mean ± *SD*. BMI = body mass index; SFT = skin-fold thickness of subcutaneous fat; SSF = sum of SFT; WHR =waist to hip ratio; TC = total cholesterol; HDL = high-density lipoprotein cholesterol; LDL = low-density lipoprotein cholesterol; TG = triglycerides.

and major differences in exercise interventions prevented meta-analysis. One showed reductions in TC and insulin following AE with small effect sizes, whilst reductions in glucose and TG with moderate effect sizes were reported[33] (**Table 2**). The other found no effect on any metabolic parameter with AE.[37]

Effects of AE on Morphological Outcomes

Body weight

Two studies compared the effects of AE versus no exercise on body weight.[31,35] No difference was found (weighted mean difference [WMD], 4.20 kg; 95% CI, –10.98, 19.39; n=68) (**Figure 2**).[31,35]

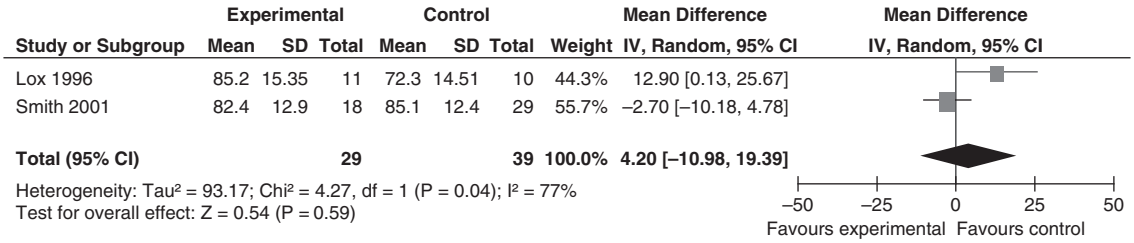

Figure 2. Aerobic exercise (AE) versus controls: body weight.

BMI

Four studies compared the effects of AE versus no exercise on BMI (**Table 4**).[31,33,35,36] Meta-analysis demonstrated a decrease in BMI with AE intervention compared with no exercise (WMD –1.31 $kg.m^{-2}$; 95% CI, –2.59, –0.03; n=186) (**Figure 3**).[31,33,35,36]

Triceps skinfold thickness of subcutaneous fat, waist to hip ratio, and waist circumference

Meta-analyses of 2 studies[31,33] found exercise training to be effective for all outcomes, with AE (compared with nonexercising controls) associated with a decrease in triceps SFT (WMD –1.83 mm; 95% CI, –2.36, –1.30; n=144) (**Figure 4**), WHR (standardised mean difference [SMD] –0.94; 95% CI, –1.30, –0.58; n=142) (**Figure 5**), and waist circumference (SMD –0.74 mm; 95% CI, –1.08, –0.39; n=142) (**Figure 6**).

Body fat mass (%)

Two studies evaluated the effects of AE on body fat mass (%), as calculated using SFT measures.[33,35] Meta-analyses found AE to decrease body fat mass (%) compared with nonexercising controls (SMD –0.37; 95% CI, –0.74, –0.01; n=118) (**Figure 7**).

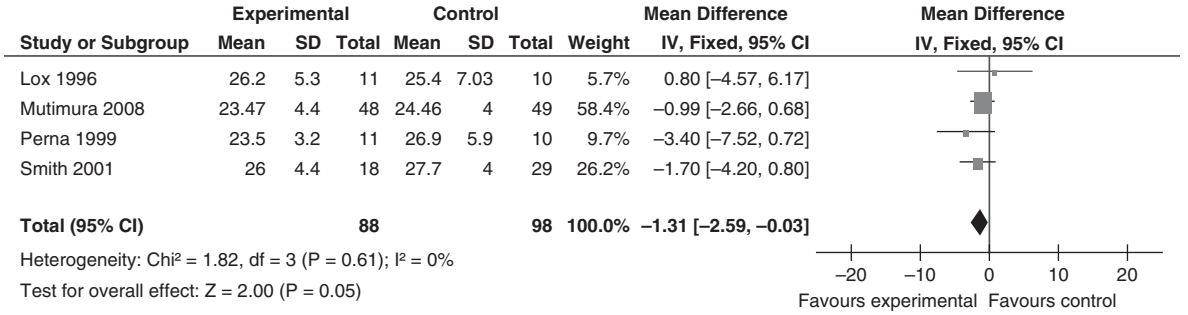

Figure 3. Aerobic exercise (AE) versus controls: body mass index (BMI).

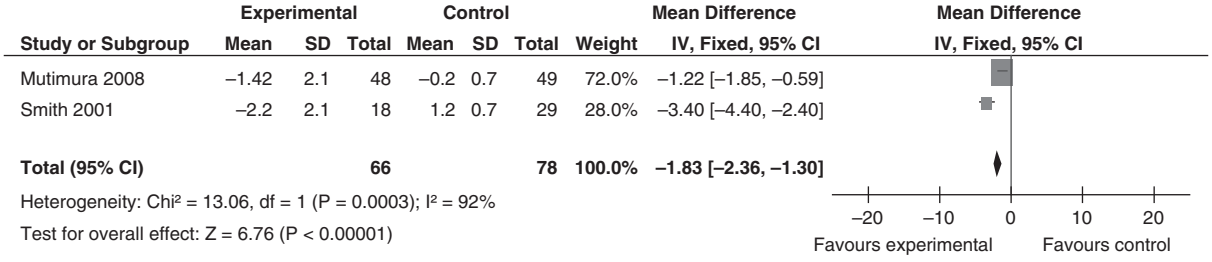

Figure 4. Aerobic exercise (AE) versus controls: triceps skinfold thickness of subcutaneous fat (SFT).

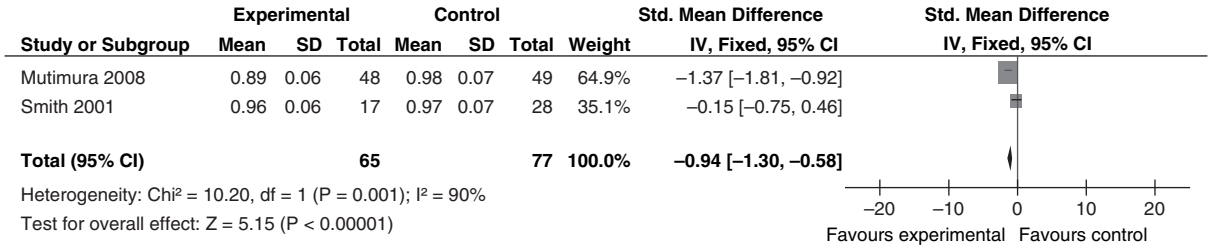

Figure 5. Aerobic exercise (AE) versus controls: waist to hip ration (WHR).

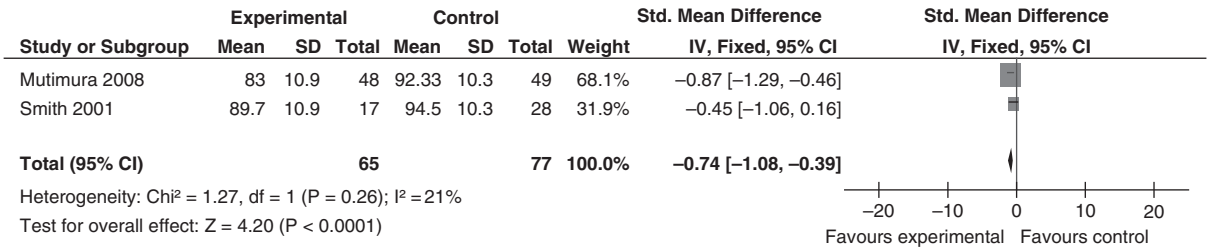

Figure 6. Aerobic exercise (AE) versus controls: waist circumference.

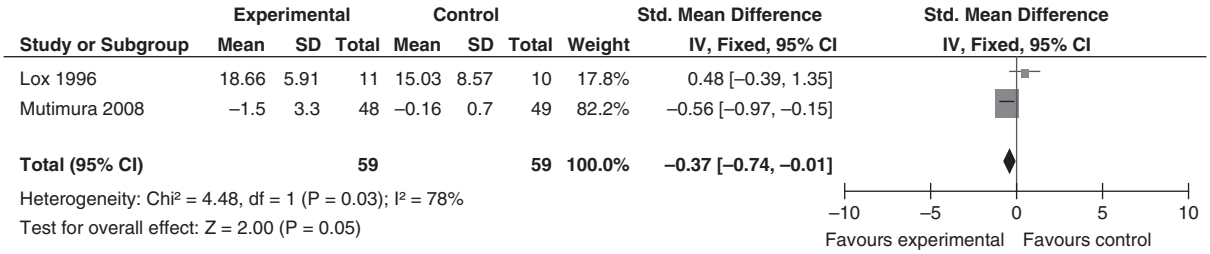

Figure 7. Aerobic exercise (AE) versus controls: body fat mass (%).

Effects of PRE on Metabolic and Morphologic Outcomes

BMI

One study demonstrated a small increase in BMI with PRE compared to nonexercising controls.[35]

Body weight

Meta-analysis of 2 studies[34,35] demonstrated increased body weight for participants in PRE groups compared with nonexercise controls (WMD 5.09 kg; 95% CI, 2.13, 8.05; n=46) (**Figure 8**).

Girth

Girth measurements were performed in 2 studies,[34,35] but measurement methods varied. Meta-analyses demonstrated an increase in the sum of arm and thigh girth in PRE groups compared with nonexercise controls (SMD 1.08 cm; 95% CI, 0.35, 1.82; n=46) (**Figure 9**).

Effects of Combined AE and PRE on Metabolic and Morphologic Outcomes

Two studies examined the effects of combined training (**Table 3**). One study found no effect on blood lipids or glucose nor on dual energy x-ray absorptiometry (DEXA) or CT measures of fat.[30] The other study demonstrated no effect on body weight.[29]

Comparison of Effects of AE and PRE on Metabolic and Morphologic Outcomes

One study compared the independent effects of AE and PRE.[32] Both exercise modalities improved insulin-mediated glucose uptake with no differences between groups. Decreases in TC and LDL and increases in HDL were greater with AE than with PRE, with large effect sizes (**Table 4**). However, PRE increased lean body mass compared to baseline [mean 2.06 kg (95% CI, 0.8, 3.3 kg)], decreased total fat [–3.3 kg (–4.6, –2.0)], trunk fat [–2.50 kg (3.5, –1.5)], and limb fat mass [–0.75 kg (–1.1, –0.4)], whereas AE did not change these measures (data not reported).

DISCUSSION

The available evidence suggests AE and PRE are effective for improving some morphological complications of chronic, treated HIV infection. AE results in decreased BMI, waist circumference, body fat mass (%), WHR, and triceps SFT. Similarly,

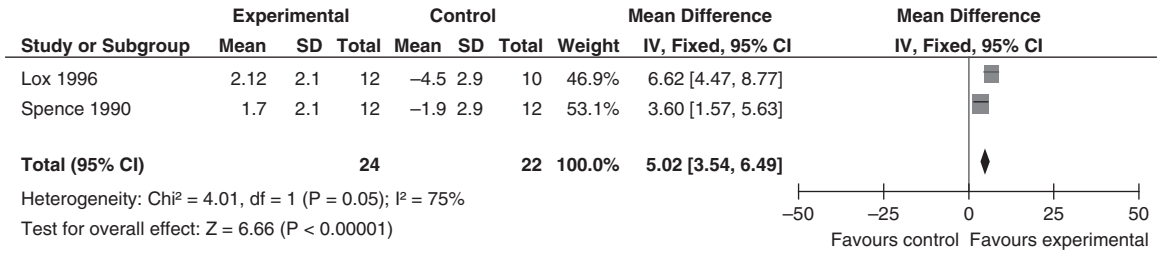

Figure 8. Progressive resistive exercise (PRE) versus controls: body weight.

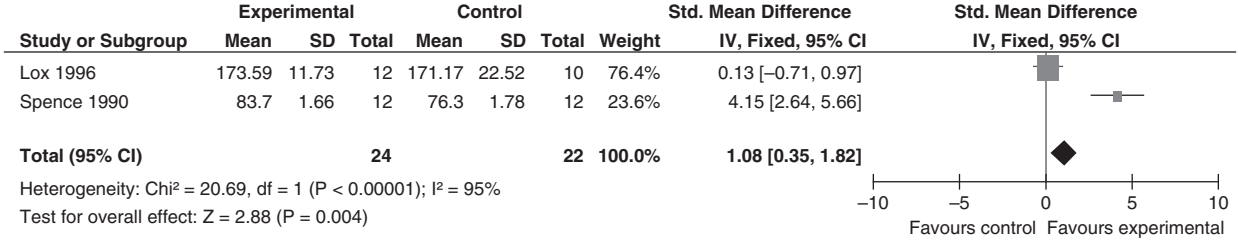

Figure 9. Progressive resistive exercise (PRE) versus controls: girth.

Table 3. Combined aerobic and progressive resistive exercise versus controls

Outcomes	Study	Treatment group	Control group	Effect size (95% CI)
Body weight, kg	Fillipas et al, 2006	1.97±3.53	–0.12±2.92	0.65 (–0.05, 1.31)
HDL, mmol/L	Dolan et al, 2006	0.026±0.225	0.078±0.236	–0.23 (–0.86, 0.42)
LDL, mmol/L	Dolan et al, 2006	0.08±0.56	0.026±0.564	0.09 (–0.55, 0.73)
Waist circumference, cm	Dolan et al, 2006	1.00±2.62	1.50±4.36	–0.14 (–0.77, 0.50)
DEXA total fat, kg	Dolan et al, 2006	–0.20±1.74	–0.70±3.05	0.20 (–0.44, 0.83)
CT SAT, cm^2	Dolan et al, 2006	3.00±34.87	–14.00±56.67	0.36 (–0.29, 0.99)
CT VAT, cm^2	Dolan et al, 2006	–2.00±30.50	8.00±30.51	–0.33 (–0.96, 0.32)

Note: Data expressed as mean ± *SD*. Change score data used to calculate effect sizes. HDL = high-density lipoprotein cholesterol; LDL, low-density lipoprotein cholesterol; DEXA, dual-energy X-ray absorptiometry; CT SAT, computed tomography subcutaneous abdominal adipose tissue; CT VAT = computed tomography visceral abdominal adipose tissue.

Table 4. Comparison of progressive resistive exercise and aerobic exercise

Outcomes	Study	PRE group	AE group	Effect size (95%CI)
HDL, mmol/L	Lindegaard et al, 2008	0.05±0.018	0.09±0.04	–1.35 (–2.30, –0.26)
LDL, mmol/L	Lindegaard et al, 2008	0.16±0.15	–0.18±0.13	2.40 (1.09, 3.48)
TG, mmol/L	Lindegaard et al, 2008	–0.38±0.31	0.01±0.12	–1.57 (–2.54, –0.44)
TC, mmol/L	Lindegaard et al, 2008	–0.02±0.22	–0.16±0.14	0.74 (–0.25, 1.66)
Glucose, mmol/L	Lindegaard et al, 2008	–0.07±0.47	0.004±0.14	0.49 (–1.67, 0.25)

Note: Data are change from baseline expressed as mean ± *SD*. Change score data used to calculate effect sizes. HDL = high-density lipoprotein cholesterol; LDL = low-density cholesterol lipoprotein; TG = triglycerides; TC = total cholesterol.

PRE has been associated with increased body weight and arm and thigh girth. Studies examining combined AE and PRE in the context of HIV are inconclusive. Limited available evidence suggests AE may be more effective than PRE in improving TC and LDL, whilst PRE is more effective than AE for improving lean muscle mass and reducing fat mass. Data are limited regarding possible benefits of any type of exercise training on metabolic outcomes in this population. We found few studies where blood lipids and glucose were examined and none that included measures of bone health. Further work is needed to understand the effects of exercise intervention on these clinically important parameters in HAART-treated HIV patients.

This is the first review to evaluate systematically the published RCT evidence for exercise training alone on metabolic and morphological outcomes in HIV-infected individuals. Previous systematic[11,12] and narrative reviews[38] on the effects of exercise training in HIV-infected patients included studies combining physical training with another treatment/pharmacological modality, making effects attributable to exercise difficult to distinguish. The current systematic review aimed to delineate the effects of exercise alone on a broader range of morphological (including imaging) and metabolic (including blood lipids and glucose) outcomes using all available RCTs in HIV-infected adults.

AE Intervention

Aerobic exercise improves blood lipids in the general population[39] and is an essential part of any exercise regimen aiming to improve blood lipids. This review found only one study evaluating blood lipid and glucose parameters with AE compared to controls and found reductions in TG and glucose with moderate effect sizes.[33] Similar lipid changes were reported in a 4-month, nonrandomised trial of AE in HIV-infected adults,[40] but further, high-quality study in this area is needed before evidence-based, population-specific recommendations can be made.

AE improves body composition and fat distribution in healthy adults by reducing total body fatness and abdominal obesity.[41] We found similar anthropomorphic improvements on meta-analyses of studies performed in HIV-infected adults, including decreased BMI, triceps SFT, body fat mass (%), waist circumference, and WHR.

PRE Intervention

PRE improves lean muscle mass, strength, and overall metabolic state and reduces adiposity in the general population.[42] This suggests PRE could improve the body composition changes associated with HIV and HIV treatments. Meta-analyses performed here found body weight and girth measures to increase with PRE in HIV-infected adults. The included studies were conducted in the pre-HAART era. Nonetheless, the results demonstrate the utility of PRE for increasing body weight and muscle mass in the context of HIV-infection – outcomes that remain desirable in many HAART-treated patients today.

PRE can improve bone mineral density and overall skeletal health.[43,44] Increased prevalence of bone disorders (eg, osteoporosis and osteopenia) are reported in HAART-treated individuals.[45] A recent longitudinal study found PRE may protect against bone loss and improve bone mineral density in HIV-infected adults.[46] Unfortunately, despite the rising prevalence of bone disease among adults with HIV infection, no included study evaluated the impact of exercise training on bone structure or function.

Combined AE and PRE Intervention

Participation in combined AE and PRE training has recently been recommended for healthy adults and those living with chronic medical conditions.[9] Despite this, little information is available from randomised trials on the effects of combined training in HIV-infected populations. Only 2 studies met our inclusion criteria, and neither found any effect on metabolic nor morphological parameters.[29,30] Similarly, the DEXA and CT data available in 1 study did not find evidence of body composition change with combined training.[30] These findings are inconsistent with other published work. Both body and trunk fat decreased with 16 weeks of thrice weekly combined training in an open-label pilot study involving HIV-infected males with lipodystrophy,[47] and blood lipids and body adiposity decreased with 10 weeks of training.[22] Further study is needed to clarify the role of combined exercise training in managing the metabolic and morphologic abnormalities associated with HIV and HIV treatments.

Comparison of Effects of AE and PRE Interventions

One study compared the effect of AE to PRE in HIV-infected adults.[32] These modes of exercise training influenced blood lipid parameters differently. No body composition changes were observed on DEXA with 16 weeks of AE,[32] however increased muscle mass and a decrease in specific fat outcomes were observed with PRE. Although this is supported by similar findings in a nonrandomised trial of an 8-week PRE program in 25 HIV-infected adults,[48] more work is needed to understand the comparative effects of AE and PRE on blood lipid and body composition.

Limitations

This review only included 9 trials, with fewer than 500 participants overall. Meta-analyses were limited by differences in exercise interventions, outcome measures, and participants. No more than 4 studies could be included in any meta-analysis, with sample sizes ranging from 46 to 186 participants. Large withdrawal rates in some studies and lack of female participants may also reduce the generalisability of findings.

This review was also limited by the quality of the available studies. Trials were of short duration, limiting knowledge on the long-term effects of exercise training which is important in the management of chronic disease. All included studies provided simplistic exercise protocol descriptions. More precise information would allow a better understanding of the effects of each program on specific outcomes. No adverse events attributable to training interventions were seen in any trial. This suggests that the dosage, intensity, frequency, and type of exercise training were safe. However, as individuals living with HIV are becoming more complex, more detailed descriptions are warranted to enhance exercise prescription for this population.

Due to the small number of RCTs available, we included trials involving both HAART-treated and non–HAART-treated patients. Although some exercise training goals are universally applicable (eg, increasing endurance), patient treatment status may result in unique exercise training objectives. For example, in patients with untreated HIV, it is typically desirable to increase body weight. However reducing body weight and central fat may be the key aim in HAART-treated individuals. We have taken care to perform and interpret meta-analyses taking this important point into consideration, with the aim of making the results relevant to current practice.

Although CT or MRI scanning are considered the gold standard for measuring central adiposity,[49] few trials used imaging to evaluate the impact of exercise on body composition. It was disappointing to find that no included studies evaluated effects of exercise training on bone health. Urgent attention is needed to address this data gap. Exercise training improves osteoporosis and osteopenia in the general population,[50] and impaired bone health is an emerging complication of chronic, treated HIV.[6]

CONCLUSION

Both AE and PRE can improve some morphological outcomes in HIV-infected individuals. Specifically, AE can improve body composition where overweight or central adiposity are of concern in HAART-treated individuals, while PRE can increase body weight and peripheral girths where reversal of muscular atrophy and weight gain are of priority. There is less available evidence for metabolic outcomes, however AE may be more efficacious than PRE on certain lipid subsets. No additional effects of combining AE and PRE on metabolic or morphologic outcomes are evident from the limited available literature. These preliminary findings need confirmation in larger, high-quality studies before evidence-based, population-specific guidelines can be developed. More emphasis is needed on improving trial quality, particularly performing intention-to-treat analyses and recruiting more participants to increase statistical power. Reporting of trials should follow the CONSORT statement.[51] With HIV management guidelines recommending earlier HAART initiation,[52] individuals on HAART are most likely to be included in future trials. Urgent work is needed to evaluate and quantify the effects of exercise training on metabolic outcomes such as blood lipids, glucose, and bone density.

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