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Review article

Exercise therapy for human immunodeficiency virus/AIDS patients: Guidelines for clinical exercise therapists

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Abstract

Human immunodeficiency virus (HIV) has infected > 60 million people since its discovery and 30 million people have died since the pandemic began. Antiretroviral therapy has transformed HIV infection from an acute to a chronic disease, increasing life expectancy but also adding to the potential side effects associated with drug therapy and the comorbidity accompanying longevity. Exercise can play a valuable role in the management of HIV/AIDS patients by addressing various symptoms and improving their quality of life, but the optimum mode, intensity, frequency, and duration of exercise that take the different clinical stages of the disease into consideration are inadequately known. Searches of Medline, Embase, Science Citation Index, CINAHL database, HealthSTAR, PsycINFO, Cochrane Central Register of Controlled Trials (CENTRAL), Cochrane Database of Systematic Reviews, Physiotherapy Evidence Database (PEDro), and SPORTDiscus were conducted between 2000 and January 2014. Searches of published and unpublished abstracts were conducted, as well as a hand search of reference lists and tables of contents of relevant journals and books. Identified studies were reviewed for methodological quality. A total of 33 studies met the inclusion criteria. Most studies failed to indicate the optimum type (mode), intensity, frequency, and duration of aerobic and progressive resistive exercise prescribed to HIV-infected individuals in relation to the different clinical stages of the disease. The purpose of this review is to provide evidence-based recommendations after revision of exercise guidelines for HIV patients, by highlighting practical guidelines that clinical exercise therapists should consider when prescribing exercise for patients in different stages of the disease.

Keywords: Aerobic exercise; CD4 count; Highly active antiretroviral therapy; Immunodeficiency progressive resistive exercise

Introduction

Health professionals are concerned to know more about the use of exercise as a complementary therapeutic modality for individuals infected with human immunodeficiency virus (HIV) because there are gaps in our knowledge regarding the optimal mode, duration, frequency, and intensity of exercises prescribed to HIV/AIDS patients. Exercise has the potential to ameliorate a range of side effects associated with HIV infection, as well as the cardiometabolic and morphological complications (i.e., mitochondrial dysfunction, inflammation, and oxidative stress) that may accompany highly active antiretroviral therapy (HAART).[1,2] Exercise can delay the progression of the disease and improve quality of life (QOL) in adults living with HIV infection.[3] In addition, exercise is generally regarded as safe because it does not compromise the immune function, and is beneficial in boosting functional capacity, strength, physical fitness, mood, and sense of well-being, and in ameliorating wasting and lipodystrophy.[1,2,4] Studies investigating the effects of exercise on cardiometabolic and morphological outcomes in people living with HIV indicate that this activity can have beneficial effects on insulin resistance and diabetes,[5,6] improve oxidative

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stress,[7,8] improve lipid profile,[7–9] and reduce risk of cardiovascular disease.[10]

Exercise studies in HIV patients have assessed the impact of aerobic exercise (AE) and progressive resistive exercise (PRE), individually or in combination, on immune function, psychological factors, cardiorespiratory fitness, strength, body composition, and QOL,[1,10] as well as HAART-induced metabolic complications[11] in HIV/AIDS patients. Results from these studies indicate that moderate- to high-intensity AE, PRE, and a combination thereof is safe and elicit favorable and beneficial changes in an HIV-infected population. These benefits include changes in body composition, functional capacity, total and high-density lipoprotein cholesterol (HDL-C), cognitive function, depression and anxiety, overall health, and QOL.[1,10] Exercise training, however, apparently confers no beneficial effect on HIV status, viral load, or immune function.[1,11] All the current clinical guidelines do not necessarily address the different disease stages when prescribing exercises to HIV/AIDS patients because it is not always possible to have a homogeneous group in HIV/AIDS exercise studies. For this reason, after carefully reviewing HIV/AIDS exercise guidelines regarding the type (mode), intensity, frequency, and duration of exercise, we describe for the first time, exercises that we believe can be applied to the different clinical stages of HIV-infected individuals.

Methods

Study design

Reviews of the published literature were conducted on the mode, intensity, frequency, and duration of exercises prescribed to HIV/AIDS patients. Only randomized trials in which 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 non-exercise intervention (e.g., anabolic steroids), English language publications, unpublished studies, and conference proceedings were excluded.

Types of participants

We included studies of adults ($\geq$ 18 years) living with HIV. Studies of men only, women only, or both at all stages of infection were included.

Types of intervention

Exercise training including AE, PRE, or a combination of both, either supervised or unsupervised, was included. AE was defined as an intervention containing AE (e.g., walking, jogging, running, rowing, or cycling). PRE was defined as resistive exercise intervention (e.g., 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. Our parameters for AE and PRE inclusion were based on the American College of Sports Medicine Guidelines.[12]

Outcome measures

Morphological outcomes considered were body weight (kg), body mass index (BMI; kg/m^2), lean body mass (kg), girth circumference (thigh, calf, arm, chest, waist, and hip; cm), percent body fat, skin fold thickness of subcutaneous fat and cross-sectional muscle area (mm^2), waist circumference (cm), waist to hip ratio (WHR), and bone mineral density (BMD). Cardiorespiratory measures considered in this review included but were not limited to maximal oxygen consumption ($V0_{2max}$; mL/kg/min), oxygen pulse, maximum heart rate (beats/min), maximum tidal volume, forced expiratory volume, minute ventilation, lactic acid threshold, maximum work rate, fatigue (time on treadmill), and dyspnea (rate of perceived exertion). Metabolic outcomes considered – all measured in mmol/L were blood lipids [total cholesterol, HDL-C, low-density lipoprotein cholesterol (LDL-C), triglycerides] and blood glucose. Immunological and virological indicators considered in this review included but were not limited to CD4/CD8 count (cells/mm^3) and viral load (log10 copies/mL). Strength measures considered for this review included but were not limited to strength (maximum amount of weight able to resist in kilograms). Psychological measures considered in this review included general measures of psychological status and health-related QOL used in studies with people living with HIV. These included but were not limited to the General Health Self-Assessment, Functional Assessment of HIV Infection, HIV/AIDS-Targeted Quality of Life Instrument, Living With HIV Scale, Medical Outcomes Study HIV Health Survey, Multidimensional QOL for Persons Living with HIV/AIDS, QOL, Medical Outcomes Study-HIV, Short Form (SF)-36, SF-12, SF-21, Quality of Life Index, Sickness Impact Profile, and Profile of Mood State Scale.

Search methods for identification of studies

The present work followed the recommendations of the PRISMA Statement which is a guideline for reporting systematic reviews.[13] Searches of Medline, Embase, Science Citation Index, CINAHL, HealthSTAR, PsycINFO, SPORTDiscus, Cochrane Central Register of Controlled Trials (CENTRAL), Cochrane Database of Systematic Review, and Physiotherapy Evidence Database (PEDro) were conducted between 2000 and January 2014. Searches of published and unpublished abstracts were conducted, as well as a hand search of reference lists and tables of contents of relevant journals and books. Three arms of the search strategy were developed and intersected using the Boolean term "AND": (1) HIV subject headings: HIV, HIV infections, HIV long-term survivors, AIDS, human immunodeficiency virus, or acquired immunodeficiency syndrome, highly active antiretroviral therapy; (2) exercise subject headings: exercise, exertion, physical fitness, sports, physical education and training, aerobic, anaerobic, progressive resistive/resistance, exercise

therapy and training; and (3) study search criteria subject headings: randomized controlled trials, random allocation, double-blind method, single blind method, clinical trials, placebos, research design, comparative study, evaluation studies, follow-up studies, prospective studies, crossover studies, intervention studies. For some databases, the search strategy was slightly modified.

Data extraction and inclusion/exclusion criteria

Two reviewers (J.G. and S.C.) independently assessed all titles and abstracts of identified studies and applied the following four inclusion criteria to determine if the abstract warranted further investigation to include/exclude a study. (1) Did the study include human participants who were HIV positive? (2) Did the study include adults aged ≥ 18 years? (3) The intervention was AE, PRE, or combined AE and PRE performed at least twice weekly for at least 4 weeks. (4) The study was a randomized controlled trial.

Full-text versions were obtained of studies that met the inclusion criteria. For any study where it was unclear whether these criteria were met, a discussion between the reviewers occurred to reach consensus. From the final group of included studies, at least two reviewers (J.G. and S.C.) abstracted data onto standard data abstraction forms independently. Abstracted data included: the study citation; study objectives; study design; length of study; time at which participants were assessed; inclusion and exclusion criteria for participants; characteristics of included participants (e.g., age, sex, and stage of disease); description of interventions (e.g., frequency, intensity, duration, type, and level of supervision); types of outcome variables assessed and their values at baseline and study completion; and number of participants at baseline and study completion (including number of withdrawals). Corresponding authors of included studies with missing data were contacted to obtain missing data where possible.

Results and discussion

The initial search identified 653 citations. Two independent reviewers screening the title and abstracts reduced this to 33 studies after elimination of duplicates and application of the inclusion and exclusion criteria.

HIV disease stages and classification

Recognizing HIV disease stages and classification systems is critical not only for tracking and for monitoring the HIV epidemic but also for providing clinicians and patients with important information about the clinical management of the disease. Clinical exercise therapists should therefore be aware of these stages as well as the varying needs during each of them in order to adjust the exercise prescription accordingly. Two major classifications are currently in use: the World Health Organization Clinical Staging and Disease Classification System and the US Centers for Disease Control and Prevention (CDC) classification system.[14] For the purpose of this article, the latter was used (Table 1) because it incorporates the CD4 cell count categories; knowledge of which is important for the clinical exercise therapist because this may dictate changes in exercise prescription.

Table 1
Centers for Disease Control and Prevention classification system for HIV-infected adults and adolescents.

CD4 cell count categories	Clinical categories		
	A Asymptomatic, acute HIV, or PGL	B Symptomatic conditions, not A or C	C AIDS-indicator conditions
≥ 500 cells/μL	A1	B1	C1
200–499 cells/μL	A2	B2	C2
< 200 cells/μL	A3	B3	C3

HIV = human immunodeficiency virus; PGL = persistent generalized lymphadenopathy.
Note. From *ACSM's Guidelines for Exercise Testing and Prescription*, 8th ed by W.R. Thompson, N.F. Gordon, and L.S. Pescatello LS, 2009. Philadelphia: Lippincot Williams and Wilkins. Copyright 20XX, *AETC*. Reprinted with permission.

The CDC categorization of HIV/AIDS is based on the lowest documented CD4 cell count and on previously diagnosed HIV-related conditions. For example, if a patient had a condition that once met the criteria for Category B but now is asymptomatic, the patient would remain in Category B. Additionally, categorization is based on specific conditions, as indicated by the AIDS Education and Training Centre.[14] Patients in Categories A3, B3, and C1–C3 are considered to have AIDS. The AIDS Education and Training Centre (AETC) can be referred to for a detailed account of the symptomatic conditions for the different clinical categories.[12,14]

Pre-exercise evaluation/testing

The literature advocates that all individuals should be screened for the presence, signs, symptoms, and/or risk factors of various cardiovascular, pulmonary, and metabolic diseases, as well as other conditions (e.g., orthopedic injury) that require special attention to: (1) aid in the development of a safe and effective exercise prescription; and (2) optimize safety during exercise testing.[12] It is therefore important that patients suffering from HIV should consult with their physician prior to starting an exercise program. Once cleared to exercise, it is recommended that the patient consult a clinical exercise therapist for advice and guidelines on his/her exercise program.

A comprehensive pre-exercise test evaluation for HIV-infected individuals includes: (1) medical history; (2) physical examination; and (3) HIV-related laboratory tests. The medical doctor should provide medical information (e.g., stage of disease, CD4 count, HAART, and other medications used, history of symptoms, and recent illness), whereas the clinical exercise therapist can acquire exercise related medical information by using the American College of Sports Medicine Physical Activity Readiness Questionnaire (PAR-Q).[12]

Clinical exercise therapists should use the Multidimensional Quality of Life Questionnaire for Persons with HIV (MQOL-HIV) to monitor health-related quality of life (HRQOL) for patients living with HIV disease.[15] HRQOL has become increasingly important with the goals of therapy now, including improvement of HRQOL, in addition to reduction of symptoms, virus suppression, and extension of survival. Routine use of this instrument could track changes in health over time; monitor, assess and optimize treatment effects; and enhance communication between patient and provider, with the potential to improve the health care process and overall survival. With physical training regarded as a non-pharmacological treatment, use of HRQOL will be helpful to monitor and improve adherence.

Despite the lower functional capacities of HIV-infected individuals, the standard physical fitness tests applicable to the apparently healthy populations can be applied.[16] Components of the physical examination conducted by the clinical exercise therapist should include the following. (1) Body composition: body weight, BMI, skin fold measurement of subcutaneous fat (fat percentage), standard circumference sites (thigh, calf, arm, chest, waist, hip) and waist to hip ratio.[11,16] Muscle mass, lean body mass,[17] and self-reported body shape changes.[18] (2) Physical capacity: conduct the modified Bruce protocol or submaximal YMCA tests to determine cardiorespiratory fitness. For assessing muscular strength, 6 repetition maximum (RM), or 10 RM protocol may be more appropriate because the affected population is generally untrained.[16] (3) Neuromuscular function: gait analysis and balance test (e.g., Stork stand) should be conducted because peripheral neuropathy which can be a consequence of fast hyperlactatemia at rest which many people living with HIV/AIDS present, is a common symptom of HIV infection. [16,19]

Recommended laboratory tests for HIV-infected individuals conducted by the medical doctor are as follows. (1) Cardiometabolic: measure fasting blood lipids (total cholesterol, LDL-C, HDL-C, and triglycerides), blood glucose, and blood pressure when diagnosed with HIV as well as prior to the start of HAART. When there is an increased risk, the test should be repeated 1–2 months after initiation of treatment. If there is no additional risk, retest 3–6 months after the start of treatment and then annually.[11,19,20] (2) Electrocardiography: due to the increased risk of heart disease, a resting 12-lead electrocardiogram is recommended.[16] (3) BMD: the literature recommends that for all HIV-infected postmenopausal women and men aged > 50 years BMD should be tested and, if normal, the test should be repeated every 2–5 years.[21]

Special considerations prior to prescribing an exercise program

Clinical exercise therapists should consider various factors when prescribing an exercise program for HIV-infected individuals. Those considerations advocated by the American College of Sports Medicine (ACSM) for the general population are also applicable to those carrying HIV.[12] Additional medication-related physical and psychological side effects such as lower gastrointestinal function (especially diarrhea), neurological complications (peripheral neuropathy), lethargy, malaise, fatigue, anemia, mitochondrial toxicity, and myopathy must be considered.[22] The following symptoms, adverse effects and comorbidity in particular should be taken into account. (1) Wasting: AIDS wasting is a syndrome of unintentional weight loss that occurs with advanced HIV infection. It is defined as a low BMI, $< 20\ kg/m^2$ or > 5–15% recent weight loss from baseline bodyweight.[23] (2) Lipodystrophy: HAART is associated with lipodystrophy, which is the redistribution of fat stores from the arms, legs, and face to the abdomen and lower cervical region.[16,22] (3) Dyslipidemia: HAART is associated with hypercholesterolemia, increases in LDL-C, hypertriglyceridemia, and HDL-C.[24] (4) Diabetes: HAART adversely affects insulin sensitivity and glucose tolerance.[24] Clinical exercise therapists should also distinguish between the three subgroups of patients with diabetes: those with pre-existing diabetes who contract HIV; those who have diabetes at onset of HIV infection; and others who develop hyperglycemia after commencing HAART. These subgroups need to be managed differently.[24] Pre-existing type 2 diabetes mellitus may continue to be managed, after diagnosis of HIV, with the same drug therapy that was being used prior to detection of HIV. It is important to counsel these patients about a possible deterioration in metabolic function, and the chances of drug interactions between oral antidiabetic drugs and HAART. Patients diagnosed with diabetes and HIV together may be treated according to guidelines for uninfected individuals. Patients developing diabetes after HAART may benefit from insulin, because it is a safe and effective method of treatment.[24] (5) BMD: Initiation of ART is associated with a 2–6% decrease in BMD over the first 2 years.[21] HIV-infected individuals receiving protease-inhibitor-based HAART (up to 30%) are more likely to display significant bone demineralization.[25] (6) Cardiometabolic disease (CMD) risk: the incidence of CMD increases in HIV-infected individuals,[16] and HAART is associated with an increase in both peripheral and coronary artery disease.[26,27] Risk factors such as hyperlipidemia, oxidative stress, impaired glucose tolerance, and increased insulin resistance, accumulation of visceral fat, inflammation secondary to HIV, and the effects of some antiretroviral drugs all contribute to the risk of developing CMD.

Program prescription

The primary goals (depending on the stage of the disease) for prescribing exercise in HIV-infected patients are to improve QOL, physical tolerance, and neuromuscular function, decrease risk of CMD, and promote long-term exercise compliance. Therefore, we should include both short- and long-term individualized goals based on the subjective and objective findings in the patient's assessment. In addition to those considerations mentioned previously, exercise should take into account: (1) the functional limitations and likes/dislikes of an individual; (2) availability of equipment and time available to train; (3) exercise dose–response (desired goal, type of exercise, and intensity, duration, and frequency of

training; and (4) coordination among members of the multidisciplinary team.[12,28] HIV/AIDS is a progressive disease, therefore, clinical exercise therapists should frequently reassess the patient's physical and neuromuscular capacity (at least every 6–8 weeks) to determine if the exercise program is still meeting the individual needs of the patient.

Reviews of exercise guidelines for HIV-infected patients are described below in terms of the FITT (frequency, intensity, time, and type) principles discussed by Oberg.[29]

Frequency

Frequency refers to how often an individual engages in an activity; usually the number of days per week.[29] Most HIV studies have used a three times weekly intervention[4,8,10] with success or three/four times per week,[16] a few studies have reported positive results twice weekly.[30,31] There should be a rest day between the sessions and, if time constraints are present, separate resistive programs into upper and lower body workouts.

Intensity

Intensity is the level of exertion experienced during the activity. Table 2 provides a breakdown of exercise intensities using objective measuring tools.[12] For the aerobic component, researchers recommend a 40–60% exercise intensity of VO_2R (difference between VO_{2max} and resting VO_2) or heart rate reserve to HIV-positive individuals.[16] Positive outcomes have been noted for low, moderate, and high exercise intensities, with moderate intensity exercise prescribed most frequently.[10] Interval training that alternates moderate and high intensity exercises has led to improved CD4 counts.[31] Only one study compared moderate to high intensity training, with better results obtained for the latter.[32]

Table 2
Classification of physical activity intensity.

Intensity	Relative intensity		Absolute intensity ranges (METs) across fitness levels			
	VO_2R (%)	MAXIMAL	12 MET	10 MET	8 MET	6 MET
	HRR (%)	HR (%)	VO_{2max}			
Very light	<20	<50	<3.2	<2.8	<2.4	<2.0
Light	20–39	50–63	3.2–5.3	2.8–4.5	2.4–3.7	2.0–3.0
Moderate	40–59	64–76	5.4–7.5	4.6–6.3	3.8–5.1	3.1–4.0
Hard (vigorous)	60–84	77–93	7.6–10.2	6.4–8.6	5.2–6.9	4.1–5.2
Very hard	≥85	≥94	≥10.3	≥8.7	≥7.0	≥5.3
Maximal	100	100	12	10	8	6

HR = heart rate (beats/min); HRR = heart rate reserve; MET = metabolic equivalent unit (1 MET = 3.5 mL/kg/min); VO_2R = oxygen uptake reserve. *Note.* Thompson WR, Gordon NF, Pescatello LS. ACSM's guidelines for exercise testing and prescription. 8th edition. Lippincot Williams and Wilkins, Philadelphia. 2009. 380p. Copyright 20XX, American College of Sports Medicine. Reprinted with permission.

PRE intensity can be measured as percentage of RM. Intensities most often prescribed to HIV-infected individuals regarding PRE start at moderate intensities of 50–60% 1 RM, and then progressively increase to higher intensities of 75–80% 1 RM after 4–12 weeks of training.[17,33,34] Training at higher intensities of up to 85% 1 RM reported no adverse effects.[24] PRE at 60–80% of 1 RM or 2–3 sets of 8–10 repetitions are recommended.[16,35,36]

Time

Time refers to the duration of an exercise session[29] and depends on the intensity as well as the goal of the exercise. AE performed at a higher intensity performed for a shorter duration produces the same results as exercise done at a moderate intensity for a longer duration. For HIV-infected individuals as little as 20 minutes of steady-state exercise[37] has been suggested to show positive results, with a higher prescribed amount of up to 1 hour also showing positive results[2,8,31] The duration most widely prescribed for AE is 30–45 minutes[10] or 30–60 minutes per session.[16] Duration of the PRE depends on the number of exercises included as well as the number of repetitions and sets. Sessions of up to 90 minutes have been recorded.[24] One can expect that combination programs will be of a longer duration with one combination program lasting 2 hours.[37]

Types (modes) of exercise

Type or mode of AE to improve the cardiovascular system includes running, walking, swimming, aerobics classes, circuit training, and cycling, whereas exercises to stress the neuromuscular system include PRE involving weights, cables/pulleys/resistance bands, body weight, and plyometrics.[8,16,29]

AE

A recent review concluded that AE is safe to perform (even at high intensities) and may lead to significant improvements in selected outcomes of cardiovascular fitness, body composition, and psychological status in HIV-infected individuals.[10] Individual studies have shown an improvement in VO_{2max} and other measures of fitness;[8,23,35] improvement in body composition (decreases in fat percentage, increases in leg muscle area, and abdominal fat loss);[8,11] reduced anxiety, stress, and depressive mood;[31] improvement in QOL;[2] as well as improvement in lipid profile[6,8,31] and glucose tolerance.[6] Crossover effects have also been reported whereby AE may lead to improved strength.[2,8,35]

PRE

PRE is safe to use and may be beneficial in medically stable adults living with HIV.[38] This kind of exercise can increase body weight and peripheral girth, and reverse muscular atrophy.[38] Training effects include an increase in strength,[8,35] improvements in body composition (increasing BMI and lean body mass),[8,39] improvements in cardiovascular fitness[8,35] and physical function,[36] as well as psychological status, QOL,[33] insulin sensitivity and lipid profile (by lowering

Table 3
Recommended FITT framework for the frequency, intensity, time, and type of AE and PRE for different HIV clinical categories.

Clinical category	Physical fitness classifications[a]	Frequency[b]		Intensity[c]			Time		Type (mode)
		Kcal/wk	d/wk	HRR/VO_2R	%HR_{max}	Perception of effort[d]	Total weekly duration per day (min)	Total weekly duration per week (min)	
A (Asymptomatic, acute HIV, or PGL)	Average–good	>2000	5 (AE) 3 (PRE)	65–80% (AE); 65–85% of 1 RM or 2–3 sets of 10–15 reps (PRE)	80–91% (AE)	Moderate–hard	30–90 (AE + PRE)	200–300	AE: cycling, walking, jogging, rowing PRE: target major muscle groups using weights, cables/pulleys/resistance bands, body weight, and plyometrics
B (Symptomatic conditions not A or C)	Fair–average	1500–2000	3–5 (AE) 2–3 (PRE)	55–70% (AE); 55–85% of 1 RM or 2 sets of 10–12 reps (PRE)	74–84% (AE)	Moderate	30–90 (AE + PRE)	200–300	AE: cycling, walking, rowing PRE: target major muscle groups using weights, cables/pulleys/resistance bands, body weight
C (AIDS – Indicator conditions)	Poor	500–1000	3 (AE) 2 (PRE)	30–45% (AE); 35–50% of (6–10 RM) or 1–2 sets of 8–10 reps (PRE)	57–67% (AE)	Light–moderate	20–30 (AE + PRE)	60–150	AE: cycling, walking, hydrotherapy PRE: target major muscle groups using cables/pulleys/ resistance bands, body weight

AE = aerobic exercise; HRR = heart rate reserve; %HR_{max} = percentage–predicted maximal heart rate; PGL = persistent generalized lymphadenopathy; PRE = progressive resistive exercise; VO_2R = oxygen uptake reserve.

Note. From Thompson WR, Gordon NF, Pescatello LS. ACSM's guidelines for exercise testing and prescription. 8th edition. Lippincot Williams and Wilkins, Philadelphia. 2009. 380p. Adapted with permission.

[a] Fitness classification based on normative fitness data categorized by VO_{2max}.

[b] Maximum frequency (d/wk) of combined AE and PRE for clinical category A = 5; B = 5; C = 3.

[c] Methods to quantify exercise intensity in this table may not necessarily be equivalent to each other.

[d] Perception of effort using the rating of perceive exertion (RPE)[13] or talk test[13]; include 5–10 minutes pre-exercise warm-up and cool-down exercises.

triglycerides).[6,8] The effect of exercise on BMD in HIV-infected individuals must still be assessed.[21]

Based on the literature cited above we designed an exercise program for the different clinical stages of HIV-infected individuals (Table 3). The program is adapted from the ACSM recommended FITT framework for the frequency, intensity, and time of exercise programs for apparently healthy adults.

In conclusion, evidence-based research indicates that exercise training (including AE and PRE and a combination thereof) by HIV-infected individuals is safe and positively influences a range of side effects associated with the HIV disease itself, as well as the cardiometabolic and morphological complications that may accompany HAART. Despite this, exercise guidelines currently available in the literature are generalized with significant gaps in knowledge as to the minimal and optimal duration, frequency, mode, and intensity of exercise needed to produce beneficial changes in HIV patients. Most of the studies to which we refer have not approached the exercise program from the perspective of validating commonly used prescriptions for physical activity or from a dose–response perspective. Our research has added to the body of knowledge of the international literature regarding exercise training for HIV-infected individuals by considering the specific clinical stages. Most importantly, it provides information that clarifies the optimal mode, duration, frequency, and intensity of AE and PRE prescribed to the different clinical stages of HIV patients. We believe that the exercises we recommend have the potential to provide much benefit to HIV patients and should be adopted by clinical exercise therapists.

Conflict of interest

The authors have no professional relationships with companies or manufacturers who will benefit from the results of the present study and the results do not constitute endorsement by anyone.

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References

1. Hand GA, Lyerly GW, Jaggers JR, et al. Impact of aerobic and resistance exercise on the health of HIV infected persons. *Am J Lifestyle Med*. 2009;3:489–499.
2. Mutimura E, Stewart A, Crowther NJ, et al. *The effects of exercise training on quality of life in HAART-treated HIV-positive Rwandan subjects with body fat redistribution Qual Life Res*. 2008;3:377–385.
3. Bopp CM, Phillips KD, Fulk LJ, et al. Physical activity and immunity in HIV infected individuals. *AIDS Care*. 2004;16:387–393.
4. Dudgeon WD, Phillips KD, Carson JA, et al. Counteracting muscle wasting in HIV-infected individuals. *HIV Med*. 2006;7:299–310.
5. Bevilacqua M, Dominguez LJ, Barbagallo M. Insulin resistance and the cardiometabolic syndrome in HIV infection. *J Cardiometab Syndr*. 2009;4:40–43.
6. Lindegaard B, Hansen T, Hvid T, et al. The effect of strength and endurance training on insulin sensitivity and fat distribution in human immunodeficiency virus-infected patients with lipodystrophy. *J Clin Endocrinol Metab*. 2008;93:3860–3869.
7. Deresz LF, Lazzarotto AR, Manfroi WC, et al. Oxidative stress and physical exercise in HIV positive individuals. *Rev Bras Med Esporte*. 2007;13:249e–252e.
8. Garcia A, Fraga G, Vieira RC, et al. Effects of combined exercise training on immunological, physical and biochemical parameters in individuals with HIV/AIDS. *J Sports Sci*. 2014;32:785–788.
9. Terry L, Sprinz E, Stein R, et al. Exercise training in HIV-1-infected individuals with dyslipidemia and lipodystrophy. *Med Sci Sports Exerc*. 2006;38:411–417.
10. O'Brien K, Nixon S, Tynan A, et al. Aerobic exercise interventions for adults living with HIV/AIDS (review). *Cochrane Database Syst Rev*. 2010;8:1–72.
11. Fillipas S, Cherry CL, Cicuttini F, et al. The effects of exercise training on metabolic and morphological outcomes for people living with HIV: a systematic review of randomised controlled trials. *HIV Clin Trials*. 2010;11:270–282.
12. Thompson WR, Gordon NF, Pescatello LS. *ACSM's Guidelines for Exercise Testing and Prescription*. 8th ed. Philadelphia: Lippincot Williams and Wilkins; 2009.
13. Moher D, Liberati A, Tetzlaff J, et al, The PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA Statement. *Ann Intern Med*. 2009;151:264–269.
14. AIDS Education and Training Centre. *Guide for HIV/AIDS Clinical Care – HRSA HIV/AIDS Bureau*; June 2012. Available from: http://aidsetc.org/guide/hiv-classification-cdc-and-who-staging-systems [cited 9 October 2014].
15. Clayson DJ, Wild DJ, Quarterman P, et al. A comparative review of health-related quality-of-life measures for use in HIV/AIDS clinical trials. *Pharmacoeconomics*. 2006;24:751–765.
16. Durstine JL. *ACSM's Exercise Management for Persons with Chronic Disease and Disabilities*. 3rd ed. Philadelphia: Lippincott Williams and Wilkins; 2009.
17. Bhasin S, Storer TW, Javanbakht M, et al. Testosterone replacement and resistance exercise in HIVinfected men with weight loss and low testosterone levels. *JAMA*. 2000;283:763–770.
18. Hsue PY, Squires K, Bolger AF, et al. Screening and assessment of coronary heart disease in HIV-infected patients. *Circulation*. 2008;18:e41–e47.
19. Prentice WE. *Rehabilitation Techniques for Sports Medicine and Athletic Training*. 5th ed. New York: McGraw Hill; 2011.
20. Neto MG, Zwirtes R, Brites C. A literature review on cardiovascular risk in human immunodeficiency virus-infected patients: implications for clinical management. *Braz J Infect Dis*. 2013;17:691–700.
21. McComsey GA, Tebas P, Shane E, et al. Bone disease in HIV infection: a practical review and recommendations for HIV care providers. *Clin Infect Dis*. 2010;51:937–946.
22. Lyles CM, Kay LS, Crepaz N, et al. Best-evidence interventions: findings from a systematic review of HIV behavioral interventions for US populations at high risk, 2000–2004. *Am J Pub Health*. 2007;97:133–143.
23. Gold J, Batterham MJ, Rekers H, et al. Effects of nandrolone decanoate compared with placebo or testosterone on HIV-associated wasting. *HIV Med*. 2006;7:146–155.
24. Kalra S, Kalra B, Agrawal N, et al. Understanding diabetes in patients with HIV/AIDS. *Diabetol Metab Syndr*. 2011;3:1–7.
25. Walker HV, Brown TT. Bone loss in the HIV-infected patient: evidence, clinical implications, and treatment strategies. *J Infect Dis*. 2012;205:S391–S398.

26. Anuurad E, Semrad A, Berglund L. Human immunodeficiency virus and highly active antiretroviral therapy-associated metabolic disorders and risk factors for cardiovascular disease. *Metab Syndr Relat Disord*. 2009;7:401−410.
27. Capili B, Anastasi JK, Ogedegbe O. HIV and general cardiovascular risk. *J Assoc Nurses AIDS Care*. 2011;2:362−375.
28. Haskell WL, Lee IM, Pate RP, et al. Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Circulation*. 2007;7:110−116.
29. Oberg E. Physical activity prescription: our best medicine. *Integrative Med*. 2007;6:18−22.
30. Scott-Sheldon LAJ, Kalichman SC, Carey MP. Stress management interventions for HIV+ adults: a meta-analysis of randomized controlled trials, 1989 to 2006. *Health Psychol*. 2008;27:129−139.
31. Thoni GJ, Fedou C, Brun JF, et al. Reduction of fat accumulation and lipid disorders by individualized light aerobic training in human immunodeficiency virus infected patients with lipodystrophy and/or dyslipidemia. *Diabetes Metab*. 2002;28:397−404.
32. Terry L, Sprinz E, Ribeiro JP. Moderate and high intensity exercise training in HIV-1 seropositive individuals: a randomized trial. *Int J Sports Med*. 1999;20:142−146.
33. Agin D, Gallagher D, Wang J, et al. Effects of whey protein and resistance exercise on body cell mass, muscle strength, and quality of life in women with HIV. *AIDS*. 2001;15:2431−2440.
34. Robinson FR, Quinn LT, Rimmer JH. Effects of high-intensity endurance and resistance exercise on HIV metabolic abnormalities: a pilot study. *Biol Res Nurs*. 2007;8:177−185.
35. Dolan SE, Frontera W, Librizzi J, et al. Effects of a supervised home-based aerobic and progressive resistance training regimen in women infected with human immunodeficiency virus. *Arch Intern Med*. 2006;166:1225−1231.
36. Pribram V. *HIV and Nutrition: Exercise and Physical Activity and Long-Term Management of HIV*. West Sussex, UK: Wiley; 2011.
37. Baigis J, Korniewicz DM, Chase G, et al. Effectiveness of a home-based exercise intervention for HIV-infected adults: a randomized trial. *J Assoc Nurses AIDS Care*. 2002;13:33−45.
38. O'Brien K, Tynan AM, Nixon S, et al. Effects of progressive resistive exercise in adults living with HIV/AIDS: systematic review and meta-analysis of randomized trials. *AIDS Care*. 2008;20:22−26.
39. Mulligan K, Zackin R, Clark RA, et al. Effect of nandrolone decanoate therapy on weight and lean body mass in HIV-infected women with weight loss: a randomized, double-blind, placebo-controlled, multicenter trial. *Arch Intern Med*. 2005;165:578−585.