Paul M. Gallo
Norwalk Community College, Norwalk, CT
188 Richards Avenue, Norwalk, CT 06854
203-857-7194
pgallo@norwalk.edu

# Human Immunodeficiency Virus, Exercise, and Function

Erlandson KM, MaWhinney S, Wilson M, Gross L, McCandless SA, Campbell TB, Kohrt WM, Schwartz R, Brown TT, Jankwoski CM. Physical function improvements with moderate or high-intensity exercise among older adults with or without HIV infection. AIDS. 2018;32:2317–26.

Human immunodeficiency virus (HIV) is a retrovirus that can be transmitted by the exchange of or exposure to bodily fluid. If untreated over time, the infection can result in acquired immunodeficiency syndrome (AIDS) (1). Through advancement in disease management and treatment, people with HIV ($HIV^+$) are living longer (>50 years) and experiencing deficits in physical function, development of frailty, and other age-related comorbidities, similar to what older adults living without HIV ($HIV^-$) experience (2). It is estimated that less than 50% of people who are $HIV^+$ have high rates of physical inactivity (3,4). Furthermore, persons who are $HIV^+$ have greater deficits in aerobic capacity when compared to persons who are $HIV^-$. These deficits are believed to be caused by mitochondrial dysfunction because of cachexia, impaired cardiac response to exercise, and/or side effects associated with use of antiviral therapy, which is standard treatment for HIV infection (1).

It is well documented that meeting the current recommendations for physical activity (4) is effective in the reduction of comorbidities associated with aging and chronic disease and improves physical function with older adults. When appropriate, vigorous (aka high) intensity exercise demonstrates additional improvements in muscular and cardiovascular fitness in older adults compared to moderate intensity exercise (4). There is evidence that resistance training and moderate intensity aerobic exercise is safe and effective for improving cardiovascular, metabolic, and physical function in younger $HIV^+$ adults (5,6). Currently, there are no studies available to determine if moderate intensity exercise results in the same health-related outcomes in older $HIV^+$ adults. Furthermore, the benefits of vigorous versus moderate intensity exercise on management of HIV have not yet been investigated (7).

## MANUSCRIPT REVIEW

The aim of this study was to determine the impact of moderate versus vigorous intensity exercise on physical function in sedentary older adults (>50 years) who are $HIV^+$ and $HIV^-$. Inclusion criteria were sedentary lifestyles (< physical activity recommendations), body mass index between 20 and 40 $kg \cdot m^{-2}$, and no contraindications to begin an exercise program (e.g., unstable angina). Participants were excluded if they had sex hormone supplementation or intramuscular testosterone injections <3 months prior. All participants with type 2 diabetes had a hemoglobin A1c ≤ 7.5%. $HIV^+$ participants were on stable antiviral therapy treatments and had a $CD4^+$ count > 200 $cells \cdot \mu L^{-1}$ ($CD4^+$ < 200 $cells \cdot \mu L^{-1}$ is diagnostic criteria for AIDS). Eighty-nine individuals completed the screening process with only 69 (32 $HIV^+$ [28 men and 4 women]; 37 $HIV^-$ [35 men and 2 women]) meeting inclusion criteria (mean age of 56 [±2] years). Thirty-nine percent of the participants had >3 comorbidities that included diabetes, hypertension, hyperlipidemia, cardiovascular disease, depression, anxiety, or bipolar disorder.

All participants underwent baseline testing, which included a treadmill-based graded exercise test, muscular strength testing, and physical function testing. During the graded exercise test, expired air was continuously measured via open-circuit spirometry along with heart rate measured via telemetry. The graded exercise test concluded when the participant requested to stop or any of the American College of Sports Medicine's test termination criteria were detected. $VO_{2\,MAX}$ was determined when 2 or more of the following criteria were met: (1) plateau in $VO_2$, (2) respiratory exchange ratio ≥ 1.10, and (3) maximum heart rate ±10 $b \cdot min^{-1}$. Muscular strength testing included the 1 repetition maximum (1RM) for 4 lifts (bench press, leg press, lateral pulldown, and a fourth alternating lift) and hand grip dynamometry. Physical function testing included the Short Physical Performance Battery (SPPB) (8), repeat chair stands, 400 m walk, and stair climb (10 steps) tests.

After baseline testing, all participants began an exercise intervention of 3 sessions per week for a total of 24 weeks. This duration included a supervised 2-week low intensity exercise acclimatization, 10 weeks of exercise intensity



Downloaded from https://prime-pdf-watermark.prime-prod.pubfactory.com/ at 2025-06-02 via free access

progression, and 12 weeks of stable moderate or vigorous intensity exercise. Baseline testing was repeated at weeks 12 and 24. Programming for low intensity exercise included 20–30 minutes of treadmill walking at 30–40% $VO_{2\,MAX}$ and 3 sets of 8 repetitions of resistance training at 40–50% 1RM for each lift tested at baseline. The 10-week progression phase included increasing aerobic exercise intensity to 40–50% $VO_{2\,MAX}$ and duration by 5 minutes per week. Resistance training intensity increased to 60–70% 1RM and was adjusted every 4 weeks based on 1RM retesting. At week 12, participants were randomly assigned to either a vigorous (60–70% $VO_{2\,MAX}$ and >80% 1RM) or a moderate intensity group (continued from first 12 weeks) for the final 12 weeks. Twenty-eight participants (13 $HIV^+$ and 15 $HIV^–$) were assigned to the moderate intensity, and 31 participants (15 $HIV^+$ and 16 $HIV^–$) were assigned to the vigorous intensity.

Outcome measures for this study were (1) weakness (assessed with hand grip), (2) slowness (assessed with 4 m walk), (3) low activity (assessed with Short Form 36 questionnaire), (4) exhaustion (assessed with the Center for Epidemiologic Studies Depression Scale), and (5) weight loss (unintentional loss ≥ 10 pounds) (9). The 5 outcome measures were used as criteria to define frailty (9). Levels of frailty included (1) frail (3/5 outcome measures), (2) intermediate frailty (1–2/5 outcome measures), or (3) not frail (0/5 outcomes measures).

Of the 69 participants who initiated the exercise intervention, 13 (19%) withdrew (4 $HIV^+$ and 6 $HIV^–$ in the first 12 weeks and 1 $HIV^+$ and 2 $HIV^–$ in the subsequent 12 weeks). The reasons provided for study withdrawal included moving out of area, new job, or unable to commit to exercise program. Forty-two (24 $HIV^+$ and 18 $HIV^–$) were classified as intermediate frailty with no participants being classified as fully frail. At baseline, the $HIV^+$ cohort had significantly poorer performance on the repeat chair raise stands, time to walk 400 m test, stair climb, and all 1RM tests when compared to the $HIV^–$ group.

When comparing groups based on HIV serostatus, both groups improved with all physical function measures in the first 12 weeks of exercise. Serostatus was defined as the difference in severity of the HIV infection according to CD4 measures. Persons with $HIV^+$ demonstrated a greater improvement in $VO_{2\,MAX}$ when compared the $HIV^–$ group in the first 12 weeks. During the second 12 weeks, the $HIV^+$ group had a greater improvement in the 400 m walking test, and stair climb test. At the conclusion of the 24-week exercise intervention, 10 participants (8 $HIV^+$ and 2 $HIV^–$) improved their SPPB scores, with no participants demonstrating poorer SPPB scores. After the exercise intervention, 13 $HIV^+$ and 7 $HIV^–$ had fewer frailty criteria when compared to baseline.

The comparison of physical function changes by exercise intensity demonstrated that both the moderate and vigorous intensity groups, regardless of HIV serostatus, significantly improved in all 1RM measures, the 400 m walk, and repeated chair stands from weeks 12 to 24. The vigorous intensity group had significantly faster 400 m walk times as compared to the moderate intensity group.

When comparing vigorous to moderate intensity exercise within the $HIV^+$ group, those who engaged in higher intensity exercise had significantly more improvements in 1RM bench press and leg press. $HIV^+$ participants in both the moderate and vigorous intensity exercise groups significantly improved on the repeat chair stand, with no significant differences in any other functional test. Both the moderate and vigorous intensity exercise decreased the number of intermediate frailty in both $HIV^+$ and $HIV^–$ individuals.

## CLINICAL IMPLICATIONS

According to the authors, this is the first study to investigate the effects of moderate intensity exercise on physical function in older adults with HIV and the first to compare the effects of moderate versus vigorous intensity exercise in persons with HIV for strength, aerobic fitness, and physical function. A major strength of this study is that nearly 85% of the $HIV^+$ participants were able to complete the 6-month exercise intervention. This suggests that both moderate and vigorous intensity exercise are safe for those who are $HIV^+$. Furthermore, both moderate and vigorous resistance and aerobic training were effective in improving $VO_{2\,MAX}$, muscular strength, and physical function, with slightly higher benefit associated with vigorous intensity exercise, especially with muscular strength of the upper and lower body.

Some precautions should be taken with interpretation of the findings of this study. Although the authors recruited both men and women, 91% of all participants in this study were men, making it difficult to apply the findings of this study to $HIV^+$ women. Although the authors state that this study is focused on older adults, they used a lower age limit of 50 years, when older adults are commonly defined as ≥65 years. Even though there is an age range of 50–75 years reported, the mean age is 56 years, which potentially makes the findings of this study less applicable to the typical older adult population, with the understanding that some $HIV^+$ individuals do not live as long, on average, as $HIV^–$ individuals. Considering the novelty of this study, findings do provide the clinical exercise physiologist with some guidance and insight to exercise programming when working with persons who are $HIV^+$.

## REFERENCES


1. Quinn TC. HIV epidemiology and effects of antiviral therapy on long-term consequences. AIDS. 2008;22(S3):1–12.
2. Piggott DA, Erlandson KM, Yarasheki KE. Frailty in HIV: epidemiology, biology, measurement interventions and research needs. Curr HIV/AIDS Rep. 2016;13:340–8.
3. Vancampfort D, Mugisha J, DeHert M, Probst M, Firth J, Gorczynski P, Stubbs B. Global physical activity levels among people living with HIV: a systematic review and meta-analysis. Disabil Rehabil. 2018;40(4):388–97.


Downloaded from https://prime-pdf-watermark.prime-prod.pubfactory.com/ at 2025-06-02 via free access

4. 2018 Physical Activity Guidelines for Americans Website [Internet]. Washington (DC): US Department of Health and Human Services; [updated 2019 Jan 3; cited 2019 Jan 4] Available at: https://health.gov/paguidelines/.
5. O'Brien KK, Tynan AM, Nixon SA, Glazier RH. Effectiveness of aerobic exercise for adults living with HIV: systematic review and meta-analysis using the Cochrane Collaboration protocol. BMC Infect Dis. 2016;16:182.
6. O'Brien KK, Tynan AM, Nixon SA, Glazier RH. Effectiveness of progressive resistive exercise (PRE) in the context of HIV: systematic review and meta-analysis using the Cochrane Collaboration protocol. BMC Infect Dis. 2017;17:268.
7. Yahiaoui A, McGough EL, Voss JG. Development of evidence based exercise recommendations for older HIV-infected patients. J Assoc Nurses AIDS Care. 2012;23:204–19.
8. Guralnik JM, Simonsick EM, Ferrucci L, Glynn RJ, Berkman LF, Blazer DG, Sherr PA, Wallace RB. A short physical performance battery assessing lower extremity function: association with self-reported disability and prediction of mortality and nursing home admission. J Gerontol. 1994; 49(2):M85–94.
9. Newman AB, Gottdiener JS, Mcburnie MA, Hirsch CH, Kop WJ, Tracy R, Walston JD, Fried LP. Associations of subclinical cardiovascular disease with frailty. J Genontol A Biol Sci Med Sci. 2001;56(3):M158–66.


## RECOMMENDED READING


Smit M, Brinkman K, Geerling C, Thyagarajan K, Sighem AC, deWolf F, Hallett TB. Future challenges for clinical care of an ageing population infected with HIV: a modelling study. Lancet Infect Dis. 2015;15(7):810–8.


Downloaded from https://prime-pdf-watermark.prime-prod.pubfactory.com/ at 2025-06-02 via free access

# Resistance Training, Neuromuscular Impairment, and Type 2 Diabetes

Botton CE, Umpierre D, Rech A, Pfeifer LO, Machado CLF, Teodoro JL, Dias AS, Pinto RS. Effects of resistance training on neuromuscular parameters in elderly with type 2 diabetes mellitus: a randomized clinical trial. Experimental Gerontology. 2018;113:141–9.

Type 2 diabetes mellitus (T2DM) is one of the most prevalent metabolic diseases with 23.1 and 1.2 million cases diagnosed in the United States (1) and Australia (2), respectively. There is an increased occurrence of T2DM associated with older adults (>65 years), which leads to greater loss of muscular strength (dynapenia) and mass (sarcopenia), resulting in impairment of physical function (3). When compared to older adults who do not have T2DM, these muscle changes occur more rapidly (3).

Loss of muscle strength and mass are associated with neuromuscular impairments and increased adipose tissue, which results in poorer muscle quality (4). Muscle quality is defined as either (1) the ratio of strength produced per unit of active mass (specific tension) or (2) the measure of echo intensity to determine intramuscular noncontractile tissue (5). When considering functionality in those with T2DM, muscle quality is an important parameter to measure, considering the disruptions of neuromuscular function, poorer glycemic control, and increased rate of intramuscular fat that are accelerated by this metabolic disease (5).

Exercise interventions such as resistance (aka weight) training are considered an important mode of management for T2DM by improving muscle quality, physical function, and glycemic control. Although most research focusing on improved muscle quality and physical function has been in non-T2DM older adults, there are a small number of randomized control trials demonstrating improved glycemic control in persons with T2DM who engage in resistance training (6). With regard to the effects of resistance training on neuromuscular and muscle quality outcomes in people living with T2DM, there is little available research.

## MANUSCRIPT REVIEW

The aim of this randomized, controlled clinical trial was to assess the effects of resistance training on neuromuscular outcomes in older adults with T2DM. Primary outcome measures included muscle quality measured using specific tension and echo intensity. Secondary outcome measures included muscle strength and thickness, functional performance, blood lipid markers, glycemic control (HbA1c), visceral adipose tissue content, and quality of life. Inclusion criteria for all participants were (1) ≥60 years, (2) diagnosed with T2DM (HbA1c > 6.5%), (3) body mass index between 18.5 and 34.9 kg·m$^{-2}$, and (4) no tobacco use for the last 6 months. The primary exclusion criteria were (1) use of insulin, (2) major chronic diseases limiting exercise, and (3) performing resistance training within the last 6 months. All participants were treated with oral antihyperglycemia medications.

The study randomized participants to either resistance training (resistance group) or static stretching (control group) 3 times per week for a 3-month duration. Testing for outcome measures was performed at 5 time points at the beginning of the study and again at the conclusion of the exercise intervention. Testing included measurement of visceral adiposity, quadriceps femoris thickness, echo intensity of the rectus femoris muscle, strength and physical function assessments, and fasting blood draws to assess glycemic control (HbA1c), cholesterol, and blood lipids. The Diabetes

Quality of Life Measure Questionnaire was also administered on a weekly basis.

For muscle quality outcomes, ultrasonography was used to measure echo intensity of the rectus femoris by use of a standard histogram grayscale function. The measurement of echo intensity allows for quantification of noncontractile intramuscular tissue. Muscle quality measured as specific tension was calculated as the ratio between knee extension 1 repetition maximum (1RM) strength and quadriceps muscle thickness. Visceral adiposity and quadriceps femoris thickness ($kg \cdot mm^{-1}$) were measured via ultrasound while in a supine position.

For muscular strength, 1RM knee extension was performed unilaterally on a variable resistance machine. Rapid strength of the knee extensors was measured using maximal isometric voluntary contractions on an isokinetic dynamometer. The rate of torque production ($N \cdot m \cdot s^{-1}$) was determined by having the participant push against the dynamometer "as hard as they can" for 3 seconds. Physical function testing included (1) sit-to-stand, (2) timed up and go, and (3) stair climbing tests.

Following baseline measures, participants were randomized to the resistance or control group to perform the exercise intervention. The resistance training routine included traditional and functional resistance exercises, following a linear periodization model. Traditional exercises included the leg press, extension, and curl, hip abduction, bench press, seated row, biceps curl, triceps extension, and abdominal crunch, and progressed from 2 sets of 12–15 repetitions to 3 sets of 10–12 repetitions with increased weights. Functional exercises included squats and step-ups following the same set and repetition changes and progressing by increasing weight or step height. The control group participated in 1 session per week of static stretching that included stretches for all major muscle groups held at 20–30 seconds and repeated 1–2 times.

Of the 44 participants (26 men and 18 women; mean age 76 [±7] years) who met inclusion criteria, 22 were randomly assigned to the resistance group (12 men and 10 women) or the control group (14 men and 8 women). Fifty-nine percent of the participants split equally between each group completed >70% of the intervention with no adverse events occurring. Disease duration ranged from 0.5–32 years.

There were no differences in muscle quality (echo intensity and specific tension) when comparing baseline with postintervention measures. No differences were detected in muscle quality between the 2 groups after the completion of the exercise intervention. Similarly, no difference was noted for rapid strength and physical function within or between the groups at the postmeasure. The resistance training group demonstrated a significant improvement of the 1RM knee extension and quadriceps thickness as compared to the control group. As expected, the control group did not improve on 1RM knee extension or quadriceps thickness.

There were no differences within or between groups for quality of life, visceral adiposity, glycemic control (HbA1C) or cholesterol (LDL and HDL) following the exercise intervention. The resistance training group demonstrated a significant reduction in triglycerides.

## CLINICAL IMPLICATIONS

Considering the limited amount of randomized clinical trials in T2DM that determine the effects of resistance training on neuromuscular function and quality of muscle, this study provides a basis for future research with this population. The findings of this study demonstrate that resistance training is an effective method to improve both muscular strength and mass in older adults diagnosed with T2DM, similar to the improvements seen in older adults who are normoglycemic. Resistance training may also be effective in improving blood profiles by reducing triglyceride levels in this population. This study demonstrates that older adults with T2DM can engage in resistance training exercises without adverse events occurring. The findings of this study reiterate the importance of prescribing resistance training as part of a management plan associated with older adults diagnosed with T2DM.

Interestingly, this study did not demonstrate improvement in neuromuscular parameters, muscle quality, rapid strength production (power), visceral adiposity, or glycemic control in the resistance training group. It is possible that the duration and/or volume of resistance programming was not enough to elicit changes in these parameters of measurement. It is well documented that muscular strength gains do not strongly correlate with rapid strength (power) production and physical function (4). Since power or explosive movements were not included as part of the training program, it is not surprising that these measures related to these movements did not improve. Future research must investigate the effects of neuromotor and power-based exercise on neuromuscular and muscle quality outcomes in persons with T2DM. Other research (6) demonstrating improved glycemic control in participants with T2DM have used younger participants (<60 years) who had poorer glycemic control (HbA1c > 7.5%) as compared to this cohort of participants. A major limiting factor associated with this study was the lack of dietary analysis. Both caloric intake and diet composition could influence the glycemic control and visceral adiposity of the participants.

## REFERENCES

1. New CDC report: more than 100 million Americans have diabetes or prediabetes [Internet]. Atlanta (GA): Centers for Disease Control Prevention; [updated 2017 Jul 19; cited 2018 Dec 19]. Available from: https://www.cdc.gov/media/releases/2017/p0718-diabetes-report.html.
2. Diabetes snapshot Web report [Internet]. Bruce (Australia): Australian Institute of Health and Welfare; [updated 2018 Jul 24; cited 2018 Dec 19]. Available from: https://www.aihw.gov.au/reports/diabetes/diabetes-snapshot/contents/how-many-australians-have-diabetes.

Downloaded from https://prime-pdf-watermark.prime-prod.pubfactory.com/ at 2025-06-02 via free access

3. Guerrero N, Bunout D, Hirsch S, Barrera G, Leiva L, Henriquez S, De la Maza MP. Premature loss of muscle mass and function in type 2 diabetes. Diabetes Res Clin Pract. 2016;117:32–8.
4. Cruz-Jentoft AJ, Baeyens JP, Bauer JM, Boirie Y, Cederholm T, Landi F, Martin FC, Michel JP, Rolland Y, Schneider SM, Topinkova E, Vandewoude M, Zamboni M. Sacropenia: European consensus on definition and diagnosis. Age and Ageing. 2010;39:412–23.
5. Nomura T, Kawae T, Kataoka H, Yukio I. Assessment of lower extremity muscle mass, muscle strength, and exercise therapy in elderly patients with diabetes mellitus. Environ Health Prev Med. 2018;23:20–9.
6. Lee J, Kim D, Kim C. Resistance training for glycemic control, muscular strength, and lean body mass in old type 2 diabetic patients: a meta-analysis. Diabet Ther. 2017;8: 459–73.

## RECOMMENDED READING

Guariguata L, Whiting DR, Hambleton I, Beagley J, Linnenkamp U, Shaw JE. Global estimates of diabetes prevalence for 2013 and projections for 2035. Diabetes Res Clin Pract. 2013;103:137–49.

Downloaded from https://prime-pdf-watermark.prime-prod.pubfactory.com/ at 2025-06-02 via free access