CLINICAL SCIENCE

Effect of progressive resistance exercise on strength evolution of elderly patients living with HIV compared to healthy controls

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OBJECTIVES: Human Immunodeficiency Virus (HIV) infection worsens the frailty of elderly people, compromising their quality of life. In this study we prospectively evaluated eleven patients living with HIV and 21 controls older than 60 years and without prior regular physical activity, who engaged in a one-year progressive resistance exercise program to compare its effects on muscular strength, physical fitness and body composition.

METHODS: Exercises for major muscular groups were performed 2 times/week, under professional supervision. Strength increase was evaluated bimonthly, while body composition, lipid and glycaemic profiles (only of those living with HIV) and physical fitness were evaluated before and after the one-year training.

RESULTS: The participants living with HIV were lighter, had smaller Body Mass Index and were initially much weaker than controls. However, their strength increased more (1.52-2.33 times the baseline values for those living with HIV x 1.21-1.48 times for controls, $p<0.01$), nullifying the differences initially seen. These effects were seen independently of gender, age or baseline physical activity. In addition, those living with HIV improved their fasting glucose levels and showed a tendency to improve their lipids after the one year training program. These effects were slightly more pronounced among those not using protease inhibitors, although not significantly.

CONCLUSIONS: Resistance exercise safely increased the strength of older patients living with HIV adults, allowing them to achieve performance levels observed among otherwise healthy controls. These findings favor the recommendation of resistance exercise for elderly adults living with HIV adults.

KEYWORDS: Exercise; HIV; Elderly adults; Muscular strength; Resistance exercise.

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INTRODUCTION

The aging process has been widely studied in the last decade, enhancing the understanding of diseases that affect elderly people and promoting a shift towards a healthier and more independent aging process. Amongst the physiological modifications observed with aging, the loss of muscular strength and functional capabilities are between the most important ones.[1]

Physical exercise has proven to be beneficial for diseases associated to aging and these benefits may result from any type of physical activity. However, resistance exercises, as the most effective method for developing musculoskeletal strength, have shown specific benefits for determined situations related to the aging process and are currently recommended by many major health organizations for improving health and fitness.[2,3]

Between those benefits are their profound effects on the musculoskeletal system that can contribute to the maintenance of functional abilities, prevent osteoporosis, sarcopenia and accompanying falls, fractures and disabilities.[4-6]

Research showing the beneficial effects of resistance exercise for the musculoskeletal system has led to recommendations for it to be included in the fitness programs for all adults, being specially recommended for older ones.[4-6] The common recommendation of the majority of resistance exercise studies is that the training program must be progressive in order to produce substantial and continued increase in muscle strength and size.[2,5]

Elderly people when sedentary for a long time can present significant decrease of muscle strength, compromising their quality of life in many important ways. Some chronic conditions, as HIV/AIDS for instances, can even worsen this situation because they potentialize the effects of aging, decreasing muscle strength and function.[7] Therefore, recovering strength and physical fitness is one major goal in patients with HIV/AIDS related frailty, to be accomplished by aerobic or resistance exercise, associated or not to testosterone and/or other anabolic steroids.[7-11]

Studies involving living with HIV adults and resistance exercise have been carried out[8,9,11] showing important benefits related to muscular strength, physical fitness and quality of life. However, to the best of our knowledge, there are none specifically comparing elderly people living with HIV with activity-, age- and gender-matched healthy controls, so far.

In a recent publication, we described that resistance exercise is safe and promotes significant increases in muscular strength and physical fitness in elderly people living with HIV, without significant adverse events or worsening of HIV/AIDS related conditions.[12] The present study compares the effects of a progressive resistance exercise program on the evolution of strength, body composition and physical fitness of older adults living with HIV with age, activity and gender matched, not-living with HIV controls. It also evaluates the lipid and fast glycaemia profile of those living with HIV before and after the one year training program.

METHODS

In this study we compare the intensity and speed of muscular strength increase, the body mass index and the physical fitness variation before and after one-year resistance exercise of elderly people living with HIV with activity, age and gender matched controls. We control the effects studied for gender, age and baseline physical activity. We also analyze the variation of total cholesterol and its fractions, triglycerides and fast glycaemia levels of those living with HIV before and after one year of resistance training.

Study design

This is a prospective, non randomized study aiming to compare the effects of a one-year resistance exercise program on muscular strength, physical fitness and body composition of elderly people living with HIV with activity-, age- and gender-matched controls, on a 1:2 ratio.

Inclusion criteria were: a) being 60 or more year's old, b) of any gender, c) without prior regular physical activity; and, d) declaring acceptance to participate.

Exclusion criteria were: a) medical contraindication to perform exercises; b) having any physical condition that limit resistance exercise; c) use of corticosteroids or anabolic steroids and d) being non adherent to the training program (defined as to stay at least 2 consecutive months away from the training program).

Subjects

As detailed elsewhere,[12] all patients living with HIV, aged 60 or more years, who were being followed up at the Hospital das Clínicas da Faculdade de Medicina da Universidade de São Paulo (HCFMUSP) were invited to join the study. Of those, twenty demonstrated interest in participate on the study, of whom 2 further refused, 2 died and 2 did not have physical conditions to participate on the training program. Thus, only 14 patients, aged between 62-70 years old (mean, 64.4 ± 3.0), of both genders and with an average 9 years history of HIV infection were included. In addition, 22 gender, age and baseline activity related not-living with HIV controls were included.

After acceptance to participate on the research, directions about the program training were given and a proper written informed consent form obtained. The Institutional Research Ethical Committee approved the study.

Training Program

The training program consisted of five different exercises aiming all major muscular groups: 1) Leg press; 2) seated row; 3) lumbar extension; 4) chest press and 5) seated abdominal. All exercises were performed using free-weights machines (Maxiflex® Biodelta, Joinville, SC, Brazil) in 3 sets of 12, 10 and 8 repetitions at light, moderate and heavy resistance, respectively, two times per week, during 1 year. We allowed participants to have 3-5 initial sections in order to get them used to the machines and exercises. The evaluation period started immediately after this initiation to the training program.

According to our training protocol, adapted from the American College of Sports Medicine recommendations,[1,2,5] sub-maximum load supported (in the heavy resistance series) was defined as the maximum weight lifted smoothly, without Valsalva maneuver, apnea or isometry. For the purposes of this work, it was considered to be a surrogate of the muscular strength. We chose this approach instead of one repetition maximum assessment test (1RM) as there is a high risk of muscular injury with this approach in frail elderly people.[13]

Sub-maximum loads supported were evaluated and adjusted whenever necessary along the training period. Variations of the sub-maximum loads supported were registered bimonthly in order to compare the pattern of muscular strength gain among elderly people living with HIV and their controls.

Weight and body mass index (BMI) were recorded at the beginning and at the ending of the training program, following standards procedures[15,16]. Data on lipid and glycaemic profiles from those living with HIV were routinely assessed in the service. In order to analyze a possible impact of the one-year resistance training program on those markers, values registered in their clinical record immediately before and after the training program were compared.

In addition, patients and their controls were also submitted to two functional tests before and after the training program in order to evaluate their physical fitness evolution. The tests included an assessment of a timed 2.4-meter walk (walking 2.4 m) at a normal pace and a timed test of five repetitions of rising from a chair and sitting down (sit-standing), according to the protocol described by Guralnik et al.[17]

Statistical Analyses

The strength evolution of each muscular group trained, evaluated by the variation observed on the average sub-maximum load lifted, the body mass index and the physical fitness were compared between those living with HIV and

their controls before and after the 12 months training period, using t-tests for independent and dependent samples, respectively. The outcome variables were controlled for age, gender and baseline physical activities, by means of bi- and multivariate analysis. In addition, regression analysis of the variation on the average load lifted for each muscular group as related to time was performed. The lipid profile and fast glycaemia levels of those living with HIV before and after the one-year training program were compared by means of the Wilcoxon matched pair test, considering both all patients and only those not using protease inhibitors. Statistica 5.5®, for Windows® software was used for the analysis, with 5% chosen as the significance level.

RESULTS

Three out of 14 patients living with HIV and one out of 22 controls abandoned the training program for more than 2 consecutive months, being therefore excluded from the study. Thus, only 11 patients living with HIV and 21 controls who completed the one-year training period remained for the final analysis.

Six out of the 11 patients living with HIV had a clinical condition defining symptomatic AIDS and 10 of them were using HAART at the time of study entrance. Of those, 10 were using nucleoside reverse transcriptase inhibitors (NRTI), 8 were using non-nucleoside reverse transcriptase inhibitors (NNRTI) and 2 were using protease inhibitors (PI). In addition, they also presented other medical conditions that prompted the use of other medications that could potentially affect the muscular response to a resistance training program. In this sense, 7 were using b-blocking agents, 4 were using statins, 4 omeprazole and 2 tiazidic diuretics, but they do not differ from controls in relation to the use of these medications. Detailed description of their clinical profiles can be found in Souza.[12]

Table 1 shows the gender and age distribution and the differences found in the outcome variables between elderly people living with HIV and their controls and, when appropriate, within each group before and after the training program.

As can be seen from the table, there were significant strength increases for all exercises, with the average loads supported increasing from 1.52 to 2.33 times the baseline values for those living with HIV. The same effect was observed for their controls, but in a lesser degree with the increase ranging from 1.21 to only 1.48 times the baseline values. The strength variation was not affected by age, baseline physical activity or gender.

In addition, table 1 show that, at baseline, those living with HIV were significantly weaker than their controls for all muscular groups tested, with the exceptions of chest press and seated abdominal. However, they gained significantly more strength than their controls, again for all muscular groups trained but pectorals and abdominals. As a consequence, at the ending of the training program those living with HIV were weaker than their controls only for leg press, in spite of having increased the strength in this particular exercise more than twice times that of controls. Again, the strength variation observed was not affected by age, baseline physical activity or gender.

Table 1 also shows the differences found in the functional tests and anthropometric variables between those living with HIV and their controls. Elderly people living with HIV tended to be lighter and had a significantly lower BMI than their controls. With respect to the functional tests, there was a significant difference at baseline in the Walking 2.4 meters test, that disappeared after the training program, with those living with HIV being faster than their controls. In contrast, in the sit-standing test those living with HIV were significantly faster than their controls at the end of the training

Table 1 - Demographic, anthropometric and functional variables of elderly people living with HIV and Controls, before and after the training program.

Variables	Living with HIV 11	Controls 21	p
Gender			
Male	5 (45.5%)	10 (47.6%)	0.907
Female	6 (54.5%)	11 (52.4%)	
Age (mean ± sd)	64.36 ± 2.98	66.95 ± 3.14	0.217
Weight (mean ± sd)			
Before	60.17 ± 14.43	69.52 ± 13.68	0.081
After	60.09 ± 13.52	69.16 ± 12.22	0.064
Difference	- 0.08 ± 1.96	- 0.37 ± 2.23	0.724
p	0.893	0.460	
Body Mass Index (mean ± sd)			
Before	23.03 ± 4.37	26.83 ± 2.99	**0.007**
After	22.99 ± 4.08	26.73 ± 2.69	**0.004**
Difference	- 0.04 ± 0.73	- 0.09 ± 0.76	0.845
P	0.848	0.559	
Functional Tests[#]			
Sit-Standing (mean ± sd)			
Before	9.25 ± 2.35	10.22 ± 2.10	0.239
After	6.58 ± 1.95	8.50 ± 1.56	**0.005**
Difference	- 2.67 ± 1.54	- 1.72 ± 1.50	0.104
P	**<0.001**	**<0.001**	
Walking 2.4 m (mean ± sd)			
Before	2.01 ± 0.38	2.43 ± 0.58	**0.036**
After	1.57 ± 0.24	1.75 ± 0.37	0.150
Difference	- 0.44 ± 0.26	- 0.68 ± 0.53	0.169
P	**<0.001**	**<0.001**	
Muscular Strength *			
Leg Press (mean ± sd)			
Before	31.05 ± 11.17	75.87 ± 20.23	**< 0.001**
After	63.18 ± 19.24	92.03 ± 20.69	**< 0.001**
Difference	32.14 ± 19.94	15.06 ± 20.24	**0.033**
P	**<0.001**	**0.005**	
Chest Press (mean ± sd)			
Before	10.24 ± 3.42	14.19 ± 8.44	0.149
After	19.59 ± 6.92	20.09 ± 11.78	0.899
Difference	9.35 ± 5.13	6.57 ± 5.49	0.182
P	**<0.001**	**<0.001**	
Lumbar Extension (mean ± sd)			
Before	28.67 ± 9.11	55.39 ± 22.71	**< 0.001**
After	66.82 ± 14.01	79.93 ± 29.70	0.183
Difference	38.14 ± 12.66	23.50 ± 20.69	**0.044**
P	**<0.001**	**<0.001**	
Seated Row (mean ± sd)			
Before	23.13 ± 5.39	39.36 ± 10.32	**<0.001**
After	50.25 ± 16.73	50.53 ± 20.24	0.971
Difference	26.81 ± 14.88	11.63 ± 15.02	**0.016**
P	**<0.001**	**0.004**	
Seated Abdominal (mean ± sd)			
Before	23.56 ± 6.18	34.39 ± 17.50	0.058
After	35.75 ± 10.61	50.85 ± 21.98	0.052
Difference	12.83 ± 9.80	17.46 ± 19.52	0.490
P	**0.003**	**0.001**	

[#]Time taken to complete the test, expressed in minutes;
*Sub-maximum load lifted, expressed in kgf

Table 2 - Lipid and blood sugar profile of elderly people living with HIV, before and after the training program.

Variables	Living with HIV 11	Without IP* 9
Total Cholesterol (mean ± sd)		
Before	220.5 ± 37.06	216.0 ± 37.59
After	219.4 ± 48.85	207.9 ± 39.32
Difference	- 1.13 ± 33.46	-8.14 ± 29.09
P	0.927	0.487
HDL Cholesterol (mean ± sd)		
Before	54.75 ± 18.36	57.29 ± 18.25
After	61.75 ± 17.95	65.29 ± 16.10
Difference	7.00 ± 16.23	8.00 ± 17.26
P	0.262	0.173
LDL Cholesterol (mean ± sd)		
Before	127.38 ± 25.76	126.29 ± 27.42
After	129.38 ± 44.02	118.43 ± 33.80
Difference	2.00 ± 33.68	- 7.86 ± 20.42
P	0.871	0.347
Triglyceride (mean ± sd)		
Before	191.13 ± 113.25	161.57 ± 82.53
After	160.00 ± 118.99	121.57 ± 52.30
Difference	- 31.13 ± 79.22	- 40.00 ± 81.16
P	0.303	0.240
Fast Glycaemia (mean ± sd)		
Before	98.25 ± 11.65	96.00 ± 9.90
After	92.38 ± 10.98	89.50 ± 11.29
Difference	- 5.88 ± 6.47	- 6.5 ± 2.88
P	0.037	0.027

*IP = protease inhibitors

program, being the difference saw at baseline not significant.

Table 2 shows the lipid profile and fast glycaemia levels variation of those living with HIV before and after the one-year resistance training program. In general, there was a slight improvement in the lipid profile of patients after the training program, although not significant. On the other hand, fast glycaemia levels were significantly reduced after the resistance training program. These results were more pronounced in those not using protease inhibitors.

The figure shows the results of the regression analysis of the average load lifted as related to time during the training program, for each muscular group trained but abdominals. The time related variation of the muscular strength of abdominal muscles were not included in this analysis because the machine used for this muscular group was changed in the 7th month of the training program, leading to an interruption on the strength gain pattern.

As can be seen from the figure, the strength increase followed a similar pattern for all muscular groups evaluated, suggesting a saturation phenomenon among controls. In contrast, for those living with HIV this pattern was not seen as they presented a linear gain on muscular strength along the one year training program, suggesting that there was still more room to a further increase in muscular strength among them. These findings were also not affected by age, gender or baseline physical activity.

DISCUSSION

An ever-growing number of published studies suggest that people living with HIV - even those with well controlled viral replication - face an increased risk of premature aging. This accelerate senescence seems especially apparent when considering metabolic and cardiovascular diseases, as well as bone thinning and frailty.[14] Resistance exercise is currently acknowledged as one of the most effective therapeutic interventions helping people to age in a healthier way.

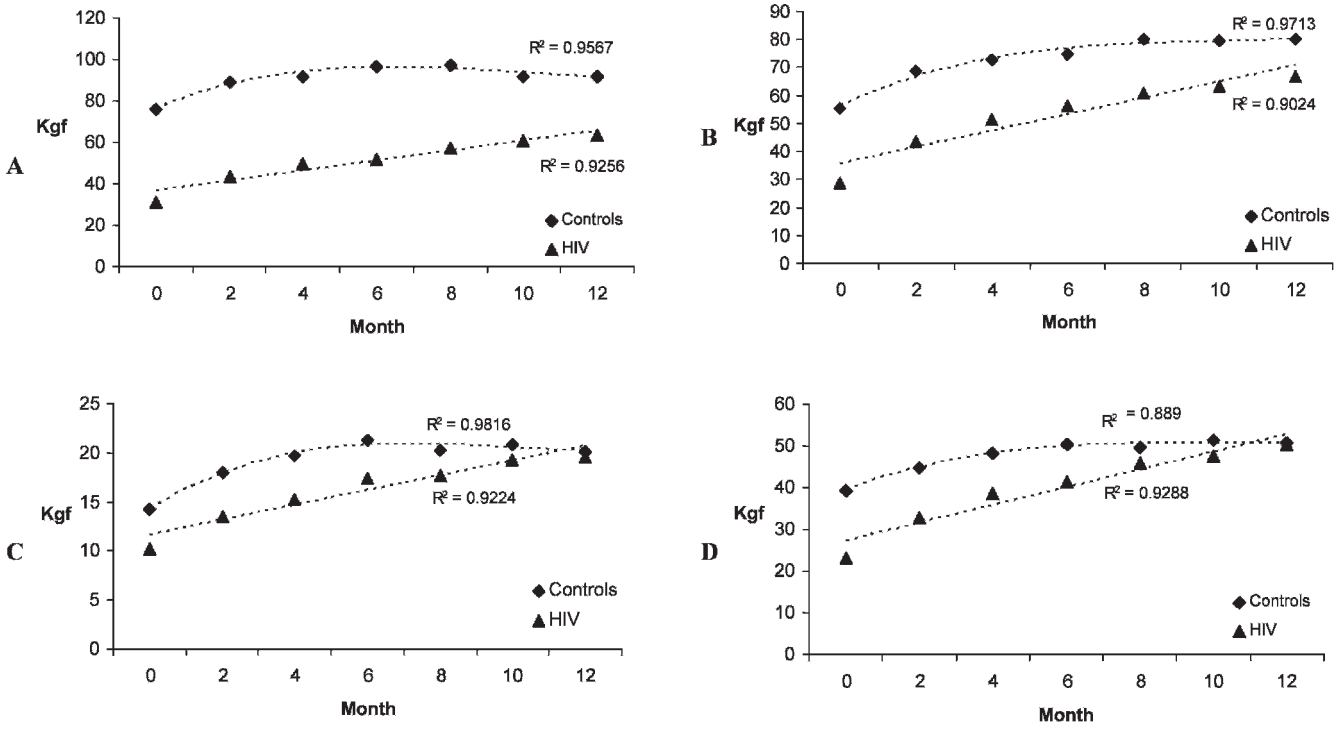

Figure. Pattern of muscular strength gain along the period of training for elderly people living with HIV and controls. **A** = Leg Press; **B** = Lumbar Extension; **C** = Chest Press; **D** = Seated Row.

Notwithstanding, to the best of our knowledge, this is the first study to compare body composition, muscular strength and physical fitness variation as a response from a progressive resistance training program between individuals older than 60 years infected by HIV and matched controls.

In a recent meta-analysis, OBrien et al.[18] reviewed the effectiveness and safety of progressive resistance exercise (PRE) interventions in adults living with HIV, finding evidence supporting that PRE appear to be safe and may be beneficial for medically-stable adults living with HIV. However, in their review they do not include any study involving people living with HIV older than 60 years. In a recent publication, Souza et al.[12] analyzed the safety and efficacy of PRE among elderly people (older than 60 years) living with HIV, with results very similar to those pointed by OBrien et al.[18]

In this study, at baseline, elderly people living with HIV were lighter and had a smaller BMI as compared to controls (Table 1). They were also significantly weaker than controls for almost every muscular group accessed, with the exception of pectorals and abdominals. But, in spite of the fact that the larger differences were seen in the extensors muscular groups related to the stand position and walking, elderly living with HIV performed better than controls in both functional tests evaluated (walking 2.4 m and sit-standing tests) after the one-year resistance training program. These findings could be partially explained by the differences seen in their weight and BMI as related to controls, as pointed above.

There was a significant and progressive strength increase for all muscular groups trained in both groups, pointing to a positive effect of the resistance training program on muscular strength, as expected. That substantial strength increase was seen in spite of their age, gender, HIV infection status and/or HIV/AIDS associated pathology or medication used, either those related to HAART or to any other chronic condition.

In addition, the pattern of strength increment among controls suggests a saturation phenomenon for all muscular groups, since the rate of increase is more prominent in the first months of training, dumping to almost null after the 6^{th}–8^{th} month of training (see figure). This pattern was not seen among elderly people living with HIV who show, in contrast, a linear increase in muscular strength throughout the training program, suggesting that the maximum possible effect attainable was not reached after the one year training program. This finding could indicate that, for those elderly living with HIV, the training program should be continued for more than one year in order to achieve the best possible results.

Intercurrences leading to small interruptions in the training program were more frequent among elderly living with HIV, but even those who experienced several intercurrences during the training period didn't suffer detraining. When they restart training it was easy for them to continue with the same load they used before the interruption. However, the abandon rate of the training program was almost 5 times greater among HIV elderly (3 : 14), as compared to their controls (1 : 22). This has already been pointed in the meta-analysis by O'Brien et al.[18,19] These differences may be a consequence of HIV related frailty and/or associated co-morbidity and suggest that PRE among them should be reinforced, but carefully accompanied and monitored.

Resistance exercise has shown other specific benefits amongst elderly people, namely: improve of cardiovascular conditioning, increase of bone mass, less possibility of fractures with aging[14] and increase of lean mass preventing decrease of strength related to aging.[20] But, undoubtedly, strength increment is the most important benefit of resistance exercise for elderly people quality of life, because it improves biomechanics and cardiovascular responses, thus facilitating daily-life activities, a positive effect referred by our study population.

The present paper, addressed to compare the resistance exercise benefits among elderly people living or not with HIV, showed, as said before, an impressive improvement in both muscular strength and physical fitness of the sample, mainly among those living with HIV. Body composition, bone mass and lipid profile did not change significantly with the one year training program. In fact, there was a slight decrease in their weight and BMI (among those living with HIV there was a slight increase in the lean mass[12]), but these changes were not statistically significant. However, fast glucose levels decrease significantly among those living with HIV, after the one year training period (Table 2). These results are also in accord with the literature.[21-23]

With respect to bone mass there were also only non-significant variations. Although somewhat disappointing, these results should be expected in view of some recent reports.[21,24,25] While vigorous skeletal loading is anabolic and efficient in adolescents and younger adults, deficits in mechanotransduction accrued with age markedly diminish the efficacy of exercise-based strategies to combat osteoporosis in the elderly.[24] In another study, Whiteford et. al.[25] pointed that, in contrast to previous findings in older women, in older men a resistance training program does not increase hip bone mass. Therefore, additional randomized controlled trials are needed to determine the most efficient training loads depending on age, sex, presence of chronic illness, current bone mass and training history for improvement of bone mass.[21]

The needs of individuals living with HIV, as longer their lives expectancy become, have increasingly included the management of problems with body function or structure, such as pain or weakness, activity limitations (difficulties an individual may have in executing activities, such as inability to walk) and participation restrictions (problems an individual may experiences in involvement in life situations).[19] Exercise is a key strategy employed by people living with HIV/AIDS and by rehabilitation professionals to address these issues. Exercise has been shown to improve strength, cardiovascular function and psychological status of adults living with HIV. However, the literature support to these conclusions is limited by the small sample sizes and large withdrawal rates described in the studies.[18,19]

In spite of the fact that the above limitations are also independently seen with ageing, leading to an expectation of an even worsen situation among elderly people living with HIV, none study, but Souza,[12] have addressed these issues specifically among older adults living with HIV so far. In this previous study we demonstrated that exercise appears to be safe and may be beneficial for older adults living with HIV. In the present study we further on our previous results by demonstrating that older adults living with HIV may have even more impressive gains in

muscular strength, physical fitness, and consequently on quality of life, than age and gender related healthy controls, allowing them to surpass their initial disadvantage due to their chronic illness, as related to controls (see Table 1 and Figure).

Finally, our results are very encouraging in pointing out the relevant benefits that a progressive resistance exercise program can bring to elderly people living with HIV, allowing them to achieve physical conditioning levels comparable to those of not-living with HIV controls, without any observed major collateral effect, endorsing its recommendation for such population. If effective and safe, exercise may enhance the effectiveness of HIV management, thus improving the overall outcome also for older adults living with HIV. Further research is required to determine the optimal parameters in which exercise may be most beneficial for older adults living with HIV.

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