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ORIGINAL RESEARCH

Implications of a twelve-week aerobic exercise on functional work capacity in HIV positive clients on antiretroviral therapy

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Abstract

The implications of aerobic exercise on functional work capacity of Human Immunodeficiency Virus (HIV) positive clients on antiretroviral therapy (ART) in Uganda have been established. ART and the efforts to scale it up have significantly improved the value of life and life's hope of among PLHIV. Despite the presence of ART HIV disease is still seen in wards and a significant loss of life due to AIDS. This study provides useful information to the Ministry of Health of Uganda on the implications of aerobic exercises on functional work capacity as a clinical outcome to HIV positive clients in Uganda. This helps in refining the existing information on aerobic exercises and their relevancy in management of HIV positive clients. An experimental study was conducted among HIV positive clients who had been on treatment for at least 12 months prior to the study. Volunteers were randomly assigned to a control group (Group 1), where no treatment was administered, and an experimental group (Group 2), where a twelve-week moderate intensity aerobic exercise was administered. Assessment of functional work capacity was done as a pre-test and post-test for both groups. The results showed that aerobic exercises significantly improved both heart rate and VO2max with p-values of <0.001 indicating a significant improvement of VO2max from 25.13 to 34.19ml/kg/min while the control group improved by 3.73ml/kg/min. Aerobic exercise can, therefore, improve the quality of life; reduce the cost of management, mobility and mortality rates in HIV positive clients on ART in Uganda.

Introduction

Human Immunodeficiency virus (HIV) has in the recent years been a global epidemiological importance with about 34 million people living with HIV (PLHIV) and 2.5 million of them have had clinical signs and symptoms of the disease. With some regional differences, HIV prevalence in Uganda is more than 1.5 people (Yebra et al., 2015). Sub-Saharan Africa, notably Uganda, faces a substantial HIV/AIDS prevalence, and it is still causing a substantial loss of life highlighting the urgent need to address the factors that contribute to poor clinical outcomes for PLHIV (West, 2021). Antiretroviral therapy (ART) has converted into a general intervention because it successfully transforms the illness from fetal to chronic illness. However, there are collateral things that affect the quality of life of patients, together with metabolic, somatic and mental conditions (Mangona et al., 2015). A big number of HIV positive employees, who are experienced and unexperienced, die in their industrious ages or fail to perform to expectation due to the infection. These are replaced by younger and others with little experience hence reduced productivity (Simtowe & Kinkingninihoun-Medagbe, 2011).

Some of the ways to handle effects of HIV and the other side effects caused by ART include exercise, exercise has been found to deliver numerous health paybacks, beginning with raised aerobic capacity to temper enhancement. It is anticipated that people with HIV can enjoy some of the benefits of workout, as the wide-ranging populace (O'Brien et al., 2016). For instance, in a meta-analysis by O'Brien et al. (2016), it displayed a raise of VO_2max by 2.63ml/kg/min for those who participated in the aerobic exercises compared to those who were not exercising control group members. There was also a significant improvement in VO_2max of 2.40 ml/kg/min for participants in the constant aerobic exercise group compared with the control group.

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Participants who were on ART also posted a significant improvement in cardiorespiratory status (maximum oxygen consumption and exercise time). Kalatzi et al. (2022) assessed the impact of supervised aerobic exercise on clinical physiological and mental parameters of people living with HIV, improved lung function was noted and a heterogeneity concerning VO_2max. Functional work capacity, which is a measure of a client's ability to carry out everyday tasks without undue fatigue, is mostly determined by looking at their maximal oxygen consumption or VO_2max (mL/kg/min). As physical fitness increases, VO_2max also increases (Maciejczyk et al., 2014) reflecting a general improvement in patient wellbeing. In HIV management, the key clinical outcomes that show client improvement or deterioration include functional work capacity (Vajpayee & Mohan, 2011).

In healthy persons without HIV infection, VO_2max rises in tandem with physical fitness. A healthy male with no training typically has a VO_2 max of 35–40 mL/(kg. min). According to Scribbans et al. (2016), the usual not trained but healthy lady has a VO_2 max of about 27–31 mL/(kg. min). Teens living with HIV had average VO_2max values in the upper 20s, putting them in the "well below average" group when compared to age-matched, HIV-negative controls (Keyser et al., 2000). Webel et al. (2019) discovered that HIV-positive patients had lower VO_2max values than an uninfected control group, both at the anaerobic threshold and throughout maximal exercise. The implications of this improvement in functional capability, however, have scarcely been assessed in Ugandan HIV-positive individuals. According to additional research, patients' ability to do activities of daily living improved steadily by 40% in a group receiving cardiac rehabilitation (Bopp et al., 2003). Greater functional capacity may lessen HIV-related symptoms and provide a higher quality of life in individuals with HIV infection, if this association is present. Engaging in frequent physical activity enables the heart to be more efficient at pumping blood. This increased efficiency means that every heartbeat, the heart can pump bigger volumes of blood, making it to pump less frequently while still maintaining an adequate blood flow to meet the body's demands. VO_2max also increases in healthy adults (Brooks, 2017). Overall, basic research on effort perception has shown that adult judgments of exercise intensity are highly correlated with physiological indices that are obtained concurrently, like heart rate, oxygen consumption, blood lactate accumulation, and others (Zinoubi et al., 2018). This study explored the implications of integrating aerobic exercise as an additional therapy for HIV-positive clients on antiretroviral therapy (ART) in Uganda, with a specific focus on its impact on functional work capacity using heart rate and oxygen consumption. This aimed at bridging a data gap in the use of aerobic exercise program on functional work capacity for HIV-positive clients.

Method

Research Design

An experimental research design was employed which is used to determine a cause-and-effect relationship. In this case the effect of aerobic exercise on functional work capacity was established. After participants volunteered to take part in the study, they were randomly allocated to the two groups that is group 1 control and group 2 experimental groups. The study design consisted of studying the experimental and control samples at two different points in time to establish change in a phenomenon or variables in order to establish the effect of 12 weeks aerobic exercise on functional work capacity. While all groups were given a pre-test, the experimental group went through a twelve-week moderate intensity aerobic exercise, and there was no treatment given to the control group at all just a follow-up call to ensure they did not feel abandoned.

Population

The study was conducted among HIV-positive female and male patients receiving care for a minimum of twelve (12) months with twenty (20) years of age and above. PLHIV on treatment for 12 months or more are expected to be stable as per the Center for Disease Control and Prevention (CDC, 2022). HIV infection is classified by the CDC (2022) into one of five stages (0, 1, 2, 3, or unknown): HIV infection is classified as stage 0 when it is expected to have occurred within six months of diagnosis, and stage 3 when it has progressed to CD4 <200, previously known as AIDS. Refer to CDC clinical classifications 1, 2, and 3.

The age range was selected with an assumption that majority of them were adults, out of schools and could allocate time for the aerobic exercise classes. After receiving health education sessions regarding the study for more than six months, 3300 of the 4,150 clients matched the purposively specified inclusion criteria, and 135 volunteers agreed to participate in the study in accordance with the established criteria and were enrolled. During the 12 weeks intervention 18

participants dropped from the study due to their own reason, and to ease comparison 18 participants were selected randomly and dropped from analysis. A flowchart of participants' selection is shown in Figure 1.

Research Instruments

RPE scale

RPE scale was used to determine maximum oxygen consumption (VO_2max) which is a common measure of functional work capacity. It is a fifteen-point category scale introduced by Borg in 1971. Borg RPE scale which uses a scale of six to twenty. This was designed to give a fairly good estimate of the actual heart rate and after getting the score we multiplied by 10 to get the estimate. The clients were taken through a 10-minute non-stop exercise by the instructors guided by music of 150 beats per minute and then the research assistants helped them to complete the RPE scale to assess the participants. Figure 2 shows that on converting the readings from the 1-10 scale to 6-20 scale and multiplying with 10 to establish the approximate heart rate.

Duke activity status index

Duke Activity Status Index (DASI) was also used to triangulate the results of functional work capacity. Both tools were administered after the 10 minutes non-stop exercise session guided by the research assistants. Then VO_2max and MET were calculated. The Duke Activity Status Index (DASI) is a method that estimates VO_{2max}, which was created by Ravani et al. (2012). Participants in the DASI were expected to select "yes" or "no" for each question. The DASI score is calculated by multiplying the total number of "yes" replies by 0.43, adding 9.6, and calculating the estimated maximum oxygen consumption (VO_2max) with 81% reliability. There is a range of 0 to 58.2 points in the final score. The functional capacity scores improve with higher scores (Olatunbosun et al., 2021).

VO_2max is calculated by obtaining the maximum heart rate which is got by multiplying age by 0.7 and deducting it from 208. Then dividing the maximum heart rate by the resting heart rate gives you the VO_2max.

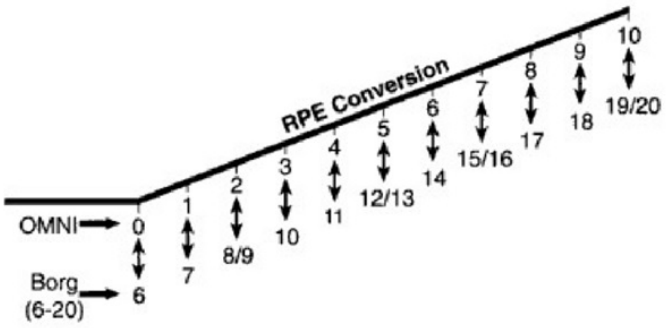

Figure 2. Scale Converter Borg 1-10 scale to Borg 6-20 scale.
Source. Panzak (2012).

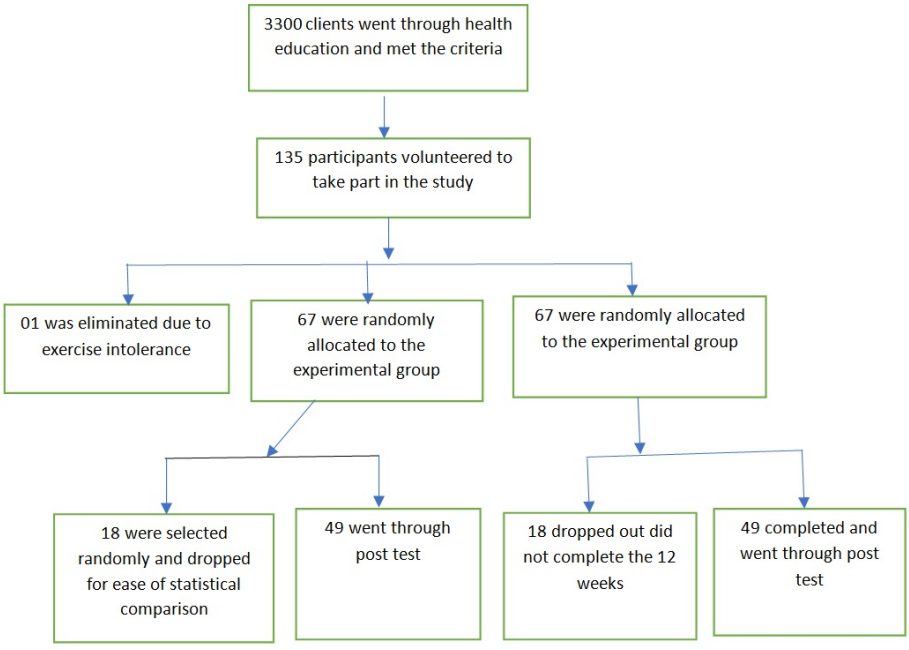

Figure 1. Flowchart of participants' selection.

Table 1
The aerobic exercise protocol that was used during the intervention.

Baseline and pre-study measurements and assessments. Beginning of sport walking phase[a] 100 – 120 bpm							
Week	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
1	Begin walking begin slowly and then increase to 120 bpm for 30 minutes general body stretching	Slow walk on spot and dance facilitated by music for 40 minutes and general body stretching	Start a walk faster than Monday for 35 minutes end the day with a general body stretch	Slow walk on spot and dance 45 minutes facilitated by music and general body stretching	Walk faster for 45 minutes end with a general body stretch	Walk at comfort and end with general body stretching	Rest
2	Walk faster for 45 minutes end with a general body stretch	Slow walk on spot and dance facilitated by music for 40 minutes and general body stretching	Start a walk faster than Monday for 45 minutes end the day with a general body stretch	Slow walk on spot and dance 45 minutes facilitated by music and general body stretching	Walk faster for 45 minutes end with a general body stretch	Walk at comfort and end with general body stretching	Rest
3	As above	As above	As above	As above	As above	As above	Rest
End of walking phase and beginning of new phase of Joggin[b] 120 to 130bpm							
4	Warm-up stretch Begin jogging for 45 minutes end the session with general body stretching	Warm-up stretch Begin jogging for 45 minutes end the session with general body stretching	Warm-up stretch Begin jogging for 45 minutes end the session with general body stretching	Warm-up stretch Begin jogging for 45 minutes end the session with general body stretching	Warm-up stretch Begin jogging for 45 minutes end the session with general body stretching	Warm-up stretch Begin jogging for 45 minutes end the session with general body stretching	Rest
5	As above	As above	As above	As above	As above	As above	Rest
6	As above	As above	As above	As above	As above	As above	Rest
Midpoint Measurement and beginning of new phase of aerobic dance[c] 130 to 140bpm							
7	Warm up dance stretch, Begin aerobic dance at 140bpm End with a general body stretch	Normal dance session end with a general body stretches	Warm up dance stretch, Begin aerobic dance at 140bpm End with a general body stretch	Warm up aerobic dance 120 bpm for 45 minutes end with a general body stretch	Warm up dance stretch, Begin aerobic dance at 140bpm End with a general body stretch	Normal dance session end with a general body stretches	
8	As above	As above	As above	As above	As above	As above	Rest
9	As above	As above	As above	As above	As above	As above	Rest
End of aerobic dance phase and beginning of combined phase of walking jogging and dance 150bpm							
10	Walk stretch the jog for 45 minutes end with a general body stretch	Warm up dance stretch then dance at 150bpm for 45 minutes general body stretch	Warm up dance stretch then dance at 15bpm for 45 minutes general body stretch	Walk stretch the jog for 45 minutes end with a general body stretch	Warm up dance stretch then dance at 150bpm for 45 minutes general body stretch	Walk stretch the jog for 45 minutes end with a general body stretch	
11	As above	As above	As above	As above	As above	As above	Rest
12	As above	As above	As above	As above	As above	As above	Rest
Post-study measurements and assessment: Continuance of lifetime physical activities							

MET is a number that indicates the relative rate at which you burn calories during an activity. Sitting quietly has an MET of 1. It is calculated as follows: Measures the participant's heart rate during an activity and divide by maximum heart rate, which are 220 minus participant's age, then multiply by 100.

Aerobic exercise protocol

The aerobic exercise session for the experimental group included frequency of exercising, intensity of the exercise, the duration. This is a 5 phases of aerobics classes which were divided into different levels of intensity and levels of difficulty: warm-up (5-10 minutes), cardiovascular conditioning (25-30 minutes), muscular strength and conditioning (10-15), then lastly a cool-down (5-10 minutes) and stretching and flexibility (5-8 minutes) the time was allocated like this to cater for progressive progression the final week the maximum time was considered see details in Table 1.

Statistical Analysis

The data were analysed using two sample t-test to compare the means for two different samples namely experimental and control group. A p-value ≤ 0.05 was considered statistically significant. The entire analysis was performed using the Statistical Package for Social Sciences (SPSS) version 20.0.

Results

The scale for rating perceived exertion follows a continuum, ranging from "very very light" to "very light," "fairly light," "somewhat hard," "hard," "very hard," and "very very hard." The results, distinguishing between the experimental and control groups, are shown in Figure 3 for pre-exertion (pre-test) and in Figure 4 for post-exertion (post-test).

Figure 3 shows that majority of the participants (33% and 30.6%) in both experimental and control group rated very very hard before the aerobic exercise. This scale was very beneficial to both experimental and control group exercisers who are doing cardio training and who would like to roughly keep track of their training heart rate.

Figure 4 show that the experimental group exercisers experience significant impact of the aerobic exercise with the change in the exertion rate from very very hard, very hard to fairly light and very light. However those in the control group didn't experience the impact of the aerobic exercise since majority of their exertion rate remain in very hard and very very hard after their exercise. This further displayed in figure 6 where the experimental group showed an improvement in oxygen consumption.

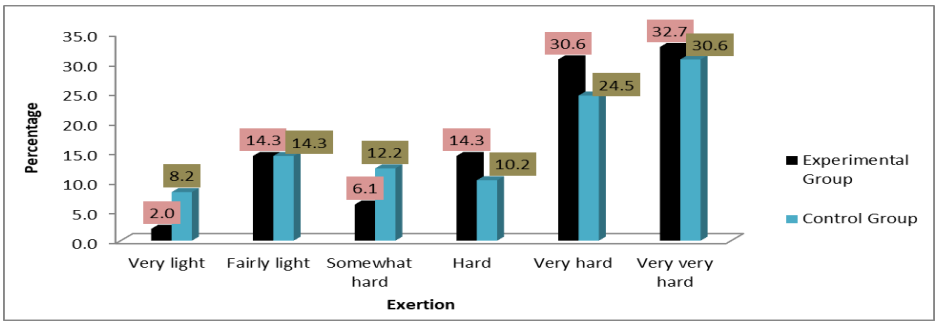

Figure 3. Pre-test results of RPE.

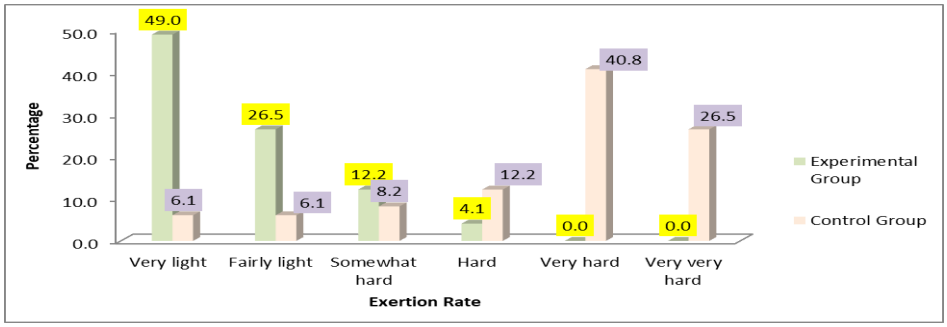

Figure 4. Post-test results of RPE.

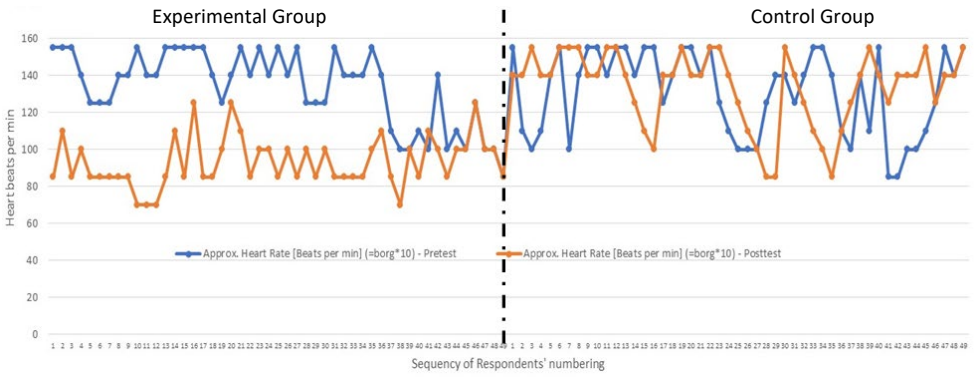

Figure 5. Results of the heart rate.

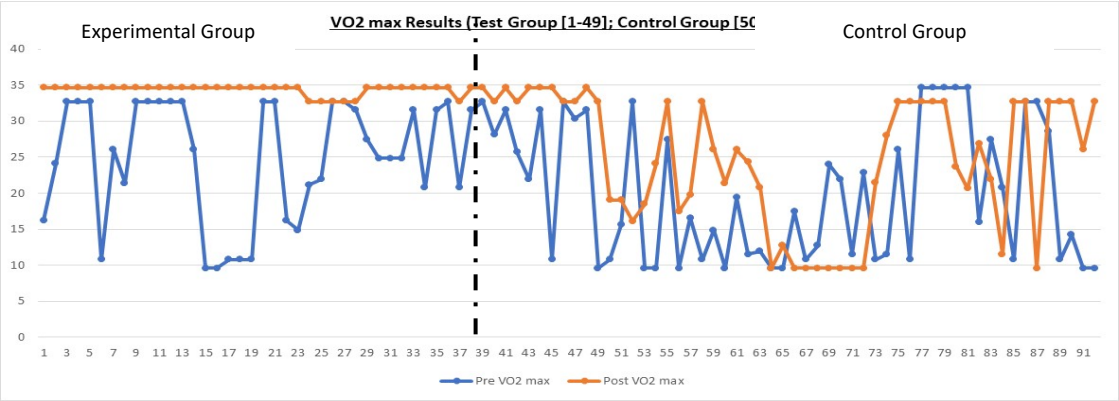

Figure 6. VO2max results.

Table 2

VO_2max values calculated from DASI.

Groups	Pre-Test Results			Post-test Results		
	Total (DASI)	VO_2 max	METs	Total (DASI)	VO_2 max	METs
Experimental Group	36.12	25.13	7.18	57.19	34.19	9.77
Control Group	20.72	18.51	5.29	29.44	22.26	6.36

As shown in Table 2, for the Experimental Group, the VO_2 max (in mL/kg/min) significantly improved from 25.13 to 34.19 mL/kg/min while that of the control group only changed slightly from 18.51 to 22.26 mL/kg/min. As indicated the DASI score ranges from 0 to 58.2 points, the higher the scores, the better the functional work capacity. Figure 6 shows a clear variation the pre-and post-test result of experimental group and control group.

Table 3

Comparison of RPE scores between experimental and control groups.

Groups	t	df	p
Experimental Group	-13.442	44	<0.05
Control Group	.664	46	.510

Table 3 shows the comparisons of RPE scores between pre-and post-tests in each group. After the aerobic exercise program, RPE scores in Experimental group significantly increased ($p < 0.05$) but there was no significant difference in RPE scores of the control group between pre-test and post-test ($p > 0.05$).

As shown in Table 4, there was a significant difference between DUKE means of pre-and post-tests ($p < 0.05$). On the other hand, no significant difference was found in DUKE of the control after the twelve-week session ($p > 0.05$).

Table 4

Comparisons the DUKE between pre-test and post-test.

Groups	t	df	p
Experimental Group	13.457	47	<0.05
Control Group	1.309	40	.198

Discussion

To assess the parameters of the aerobic exercise as conducted, the RPE scale was utilized. This scale has been presented differently by different scholars although with the same message. For instance, Lea et al. (2022) used it to study the convergent of ratings of perceived exertion during resistance exercise in healthy participants.

The results upon conducting the ten minutes exercise were clear that the post-test scores for the experimental group of the perceived exertion shifted the higher scales of 'hard to very hard' to the lower part of the scale of 'very light to fairly light' expressing that the subject were more physically fit than before and indicates improvement in VO_2max hence improved performance. This was confirmed by the fact that the pre-test and post-test results of the control group remained fairly the same. Nystoriak & Bhatnagar (2018) alludes that regular exercise has numerous benefits for the cardiovascular system, together with making the heart muscles strong. Engaging in regular physical activity makes the heart more efficient at pumping blood. What should be noted

is that, a strong heart muscle is a crucial component in improving oxygen uptake and VO_2max it pumps more blood that makes oxygen delivery better (Zheng et al., 2022).

A T-test was done and results imply that the aerobic exercises indeed improve the functional work capacity of HIV positive clients on ART. This was comparable to research that examined the efficacy of aerobic exercise for adults living with HIV: a systematic review and meta-analysis employing the Cochrane Collaboration protocol exercise group ended the 20-minute multi-stage shuttle run test (20mMST) with a higher heart rate and rate of perceived exertion (RPE). According to the 20mMST, VO_2max significantly improved among exercisers when you relate them to people who were not exercising (O'Brien et al., 2016).

The results show an improvement in oxygen consumption as indicate on the left side of Figure 6 where the experimental group are on the left and the control group on the right. The blue line is pre-test while the pink is post-test. These findings are consistent with those of O'Brien et al. (2016), who discovered that engaging in aerobic exercise, or a mix of aerobic and resistive exercise, three times a week for five weeks or more, is safe and can enhance the quality of life, strength, body composition, and cardiorespiratory fitness in adults living with HIV.

Considering that the p-value of the experimental group in this case was <.001 which was less than the alpha level (.005) since a 95% level of significance was considered in this test, this means that the aerobic exercises statistically significantly increased oxygen consumption hence, improving functional work capacity of the HIV positive clients on ART in Uganda. These results agree with a study of Riedel et al. (2021), where there was an improvement in functional work capacity measured using the DASI, and that of O'Brien et al. (2016), where the participants exhibited a greater improvement in functional work capacity.

The findings, which as summarized, are consistent with those of O'Brien et al. (2016), who found that doing aerobic exercise three times a week for at least five weeks can improve strength, body composition, cardiorespiratory fitness, and quality of life of HIV positive clients. The findings corroborate previous findings by Warburton et al. (2006) and Penedo & Dahn (2005) that exercise does, in fact, have a beneficial effect on strength, cardiovascular function, and psychological status even in non-patients. The results of this study were also consistent with those of Stanley et al. (2017), who also showed that exercise improves the general health and wellbeing of the HIV population, and of Jaggers et al., (2014), who found that exercise and physical activity are safe and effective ways to improve the metabolic profile, cardiorespiratory fitness, and quality of life in people living with HIV.

Conclusions

VO_2max scores were increased from 19.9 to 48.68 which indicated a significant improvement in functional work capacity for HIV positive clients in ART care. In addition, heart rate significantly lowered even when the participants were given the same challenge indicating an improvement in heart efficiency. The use of RPE and DASI gives almost the same results when measuring oxygen consumption to determine functional work capacity. With RPE, there was a clear shift to a score below ten indicating the exercise was very simple for the experimental group during post-test. Aerobic exercise is therefore a powerful tool to enhance functional work capacity and overall quality of life for HIV positive clients on ART. This can be archived by following proper guidelines where clients can safely and effectively improve their health outcomes and quality of life for people living with HIV in Uganda.

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Authors' Contribution

Study Design: MN; CANN; EO; Data Collection: MN; Statistical Analysis: MM; Manuscript Preparation: MN; CANN; EO; MM.

Ethical Approval

The Study was approved by the Lacor Hospital Institutional Research and Ethical Committee (RHIREC; No: 0183/07/2020) and it was carried out in accordance with the Code of Ethics of the World Medical Association also known as a declaration of Helsinki. And thereafter approved by Uganda National Council for Science and Technology Ref: HS 1276ES.

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Conflict of interest

The authors hereby declare that there was no conflict of interest in conducting this study.

Data availability

The data sets generated and analysed during the study are available from the corresponding author on reasonable request.

References

Bopp, C., Phillips, K. D., Fulk, L. J., & Hand, G. A. (2003). Clinical implications of therapeutic exercise in HIV/AIDS. *J Assoc Nurses AIDS Care*, 14(1), 73-78.

Brooks, C. (2017). *The effect of a CPET familiarization session on aerobic capacity (VO_{2max}) in sedentary middle-aged females* [Master's thesis]. University of North Carolina.

Burnley, M., & Jones, A. M. (2007). Oxygen uptake kinetics as a determinant of sports performance. *European Journal of Sport Science*, 7(2), 63-79.

CDC, (Center for Disease Control and Prevention, 2022). *Perceived exertion (Borg rating of perceived exertion scale).* Retrieved June 28, 2024, from https://www.cdc.gov/physicalactivity/basics/measuring/exertion.htm

Jaggers, J. R., Hand, G. A., Dudgeon, W. D., Burgess, S., Phillips, K. D., Durstine, J. L., & Blair, S. N. (2014). Aerobic and resistance training improves mood state among adults living with HIV. *Int J Sports Med*, 36(2), 175-181.

Kalatzi, P., Dinas, P. C., Chryssanthopoulos, C., Karatzanos, E., Nanas, S., & Philippou, A. (2022). Impact of supervised aerobic exercise on clinical physiological and mental parameters of people living with HIV: a systematic review and meta-analyses of randomized controlled trials. *HIV Res Clin Pract*, *23*(1), 107-119.

Keyser, R. E., Peralta, L., Cade, W. T., Miller, S., & Anixt, J. (2000). Functional aerobic impairment in adolescents seropositive for HIV: a quasiexperimental analysis. *Arch Phys Med Rehabil*, *81*(11), 1479-1484.

Lea, J. W., O'Driscoll, J. M., Hulbert, S., Scales, J., & Wiles, J. D. (2022). Convergent validity of ratings of perceived exertion during resistance exercise in healthy participants: a systematic review and meta-analysis. *Sports Medicine Open*, *8*(1), 2.

Maciejczyk, M., Więcek, M., Szymura, J., Szyguła, Z., Wiecha, S., & Cempla, J. (2014). The influence of increased body fat or lean body mass on aerobic performance. *PloS One*, *9*(4), e95797.

Mangona, L., Daca, T., Tchonga, F., Bule, O., Bhatt, N., Jani, I., ... & Prista, A. (2015). Suppl 1: M5: effect of different types of exercise in HIV+ Mozambican women using antiretroviral therapy. *Open AIDS J, 9, 89-95.*

Nystoriak, M. A., & Bhatnagar, A. (2018). Cardiovascular effects and benefits of exercise. *Front Cardiovasc Med*, *5*, 135.

O'Brien, K., Tynan, A. M., Nixon, S., & Glazier, R. H. (2008). Effects of progressive resistive exercise in adults living with HIV/AIDS: systematic review and meta-analysis of randomized trials. *AIDS Care*, *20*(6), 631-653.

O'Brien, K. K., Tynan, A. M., Nixon, S. A., & Glazier, R. H. (2016). Effectiveness of aerobic exercise for adults living with HIV: systematic review and meta-analysis using the Cochrane Collaboration protocol. *BMC Infect Dis*, *16*, 182.

Olatunbosun, T. O., Awotidebe, T. O., Adedoyin, R. A., Fasakin, O. M., & Ogunyemi, S. A. (2021). Correlation between self-reported daily activity and submaximal walk test in the assessment of functional capacity among patients with hypertension. *Int J Clin Cardiol*, 8, 238.

Penedo, F. J., & Dahn, J. R. (2005). Exercise and well-being: a review of mental and physical health benefits associated with physical activity. *Curr Opin Psychiatry*, *18*(2), 189-193.

Ravani, P., Kilb, B., Bedi, H., Groeneveld, S., Yilmaz, S., Mustata, S., & Alberta Kidney Disease Network. (2012). The Duke Activity Status Index in patients with chronic kidney disease: a reliability study. *Clinical Journal of the American Society of Nephrology*, *7*(4), 573-580.

Riedel, B., Li, M. H., Lee, C. A., Ismail, H., Cuthbertson, B. H., Wijeysundera, D. N., ... & Edwards, M. (2021). A simplified (modified) Duke Activity Status Index (M-DASI) to characterise functional capacity: a secondary analysis of the Measurement of Exercise Tolerance before Surgery (METS) study. *Br J Anaesth*, *126*(1), 181-190.

Scribbans, T. D., Vecsey, S., Hankinson, P. B., Foster, W. S., & Gurd, B. J. (2016). The effect of training intensity on VO_{2max} in young healthy adults: a meta-regression and meta-analysis. *Int J Exerc Sci*, *9*(2), 230.

Simtowe, F., & Kinkingninhoun-Medagbe, F. M. (2011). The impact of HIV/AIDS on labor markets, productivity and welfare in Southern Africa: A critical review and analysis. *Afr J Agric Res*, *6*(10), 2118-2131.

Stanley, M. M., Wadzani, G., Adamu, B., Amina, K., Oyeyemi, A. Y., Umeonwuka, C. I., & Akanbi OA. (2017). Aerobic exercise improves quality of life and CD4 cell counts in HIV seropositives in Nigeria. *J Hum Virol Retrovirol*, 5(3), 00151.

Vajpayee, M., & Mohan, T. (2011). Current practices in laboratory monitoring of HIV infection. *Indian J Med Res, 134(6), 801-822.*

Warburton, D. E., Nicol, C. W., & Bredin, S. S. (2006). Health benefits of physical activity: the evidence. *CMAJ*, 174(6), 801-809.

Webel, A. R., Jenkins, T., Longenecker, C. T., Vest, M., Davey, C. H., Currie, J., ... & Josephson, R. A. (2019). Relationship of HIV status and fatigue, cardiorespiratory fitness, myokines and physical activity. *J Assoc Nurses AIDS Care,* 30(4), 392–404.

West, N. S. (2021). *Mental health among people living with HIV and impacts on the HIV care continuum: a focus on Rakai, Uganda* [Doctoral dissertation]. Johns Hopkins University.

Yebra, G., Ragonnet-Cronin, M., Ssemwanga, D., Parry, C. M., Logue, C. H., Cane, P. A., ... & Brown, A. J. L. (2015). Analysis of the history and spread of HIV-1 in Uganda using phylodynamics. *J Gen Virol*, 96(Pt 7), 1890-1898.

Zheng, J., Pan, T., Jiang, Y., & Shen, Y. (2022). Effects of Short-and Long-Term Detraining on Maximal Oxygen Uptake in Athletes: A Systematic Review and Meta-Analysis. *Biomed Res Int*, 2022, 2130993.

Zinoubi, B., Zbidi, S., Vandewalle, H., Chamari, K., & Driss, T. (2018). Relationships between RPE, heart rate and blood lactate during continuous and alternated-intensity cycling exercises. *Biol Sport*, 35(1), 29-37.