OPEN ACCESS
Turkish Journal of Kinesiology

ORIGINAL RESEARCH

Aerobic-training effects on CD4 cell count and health related quality of life of people living with human immunodeficiency virus

Thabo Muswere[1], Ignatius Ugo Onyewadume[2]

[1] Department of the Physical Education, Serowe College of Education, Serowe, Botswana. [2] Department of the Physical Education, Faculty of Education, University of Botswana, Gaborone, Botswana.

Received:
October 13, 2023

Accepted:
January 23, 2024

Online Published:
March 25, 2024

Keywords:
Aerobic training, CD4 cell count, highly active antiretroviral therapy (HAART), human immunodeficiency virus (HIV), health related quality of life (HRQoL).

Abstract

This study compared the effects of 12 weeks of aerobic training against baseline data of People Living with Human Immunodeficiency Virus (PLWH) Cluster of Differentiation 4 (CD4) cell count, and Health-Related Quality of life (HRQoL) (Physical-health Component Summary (PCS) and Mental-health Component Summary (MCS)). A within-subject quasi-experimental multimethod design was used. There was purposive sampling of participants on Highly Active Antiretroviral Therapy (HAART) under Botswana Network of People Living with HIV/AIDS (BONEPWA). The 28 participants (23 females and 5 males) who met the inclusion criteria were of age 18 to 45. After 6 weeks, one female dropped out of the study. Participants were subjected to 12 weeks of aerobic training, three times a week for 60 minutes per session. The significant differences between CD4 cell count and the HRQoL variables at baseline and week 12 of the participants were compared using the paired t-test. All analysis was done using Statistical Package for the Social Sciences (SPSS) version 24.0 software. The alpha value was set at $p<0.05$ level of significance. The mean age and standard deviation of participants was 37.7 (± 6.84) years. Statistically significant ($p< 0.05$) improvements were found in MCS measures after intervention. There were no statistically significant ($p>0.05$) improvements in CD4 count and PCS measures after intervention. PLWH can be advised to engage in regular aerobic training 3 times a week for 60 minutes especially when on HAART. The research is relatively preliminary; therefore, there could be some replication of the study by other researchers.

Introduction

Human immunodeficiency virus (HIV) infection is one of the public health problems in many countries including Botswana (United States Presidential Emergency Plan for AIDS Relief [USPEPFAR], 2020). As one of the hardest hit countries in the world, Botswana has the fourth highest HIV prevalence after South Africa, Lesotho and Eswatini (Avert | Global Information and Education on HIV and AIDS, 2021). In 2017, Botswana had a projected 378 184 people living with human immunodeficiency virus (PLWH) and in 2021 there were estimated 364 437 PLWH in Botswana (USPEPFAR, 2018; USPEPFAR, 2022). The number of new HIV infections in Botswana has steadily decreased since 2010 from 14 000 new infections to 6 728 new infections in 2021 (Global AIDS monitoring, 2020; USPEPFAR, 2022). The infection is largely concentrated in Greater Gaborone and Greater Francistown and highest among older population aged 25 years and above (USPEPFAR, 2019 & 2020). Often, PLWH experience muscle pain, loss of lean body mass and fatigue which lead to reduced aerobic capacity, limiting their work participation and activities of daily living (Chisati & Vasseljen, 2015). Some individuals end up living a sedentary lifestyle that affects other aspects of their health.

CD4 cell count is one of the important markers of health in PLWH. Most PLWH in Sub-Saharan Africa initiate antiretroviral therapy at very low CD4 counts despite the increase in median CD4 cell count antiretroviral initiation by the World Health Organisation (Angelo & Alemayehu, 2020; Laher et al., 2021). Though it is a good effort, low CD4 cell count and advanced stages of the disease are the most important predictors of clinical progression and poor survival after antiretroviral initiation (Pantazis et al., 2023). Patients who initiate HAART at low CD4 cell

✉ T. Muswere, e-mail: bubbyth@gmail.com
To Cite: Muswere, T., & Onyewadume, I. U. (2024). Aerobic-training effects on CD4 cell count and health related quality of life of people living with human immunodeficiency virus. *Turk J Kinesiol*, 10(1), 10-17. **DOI:** 10.31459/turkjkin.1375448

count levels, remain at risk of opportunistic infections for a very long period than patients starting HAART at higher CD4 cell count levels.

It is worth noting that the HIV, its symptoms, and complications have a negative effect on the health-related quality of life (HRQoL) of PLWH (Algaralleh et al., 2020). Changes associated with HIV and HAART affect body image and influence HRQoL which contains domains that are vital indicators of living status (Girma et al., 2023). Gomes-Neto, Conceicao, Ogalha and Brites (2016) reported that functional impairment is common among PLWH; so, lifestyle modification should be a priority in the management of chronic HIV disease.

In knowing the advantages and disadvantages of early and late HAART initiation, Botswana has adopted the 'Treat All' strategy where all people including foreign residents eligible for HAART, are enrolled into the program and given treatment as per World Health Organization guidelines (United Nations Program on HIV/AIDS [UNAIDS], 2019). Antiretroviral therapy clinics in Botswana comply with national and international guidelines. Also, it is the first country in Sub-Saharan Africa to offer universal access to HIV care (Ramogola-Masire et al., 2020). People in different countries are treated in different ways when it comes to HIV therapy; some take long to be initiated into HAART. There are other countries where research involved people who were not on HAART. In Malawi, Chisati & Vasseljen (2015) did a study involving PLWH who were not on HAART therapy comparing them to HIV-negative people. Botswana is different, as everyone is initiated into HAART upon testing positive to HIV; hence the need to conduct a study relevant to the nation.

This study aimed at comparing the effects of 12 weeks of aerobic training against baseline data of PLWH's CD4 cell count and HRQoL [Physical-health Component Summary (PCS) and Mental-health Component Summary (MCS)]. The following hypotheses were formulated to guide the study: a) There will be no significant difference in CD4 cell count of PLWH before and after twelve weeks of aerobic training. b) There will be no significant difference in HRQoL of PLWH before and after twelve weeks of aerobic training looking at their PCS and MCS measures.

Methods

Research Design

The research was a within-subjects quasi-experimental multimethod design. According to Creswell (2015) when multiple forms of quantitative data (for example, survey data and experimental data) are collected, the term is multimethod research. After all the pretests were done, the participants were all assigned to aerobic training (Figure 1).

Participants

The study targeted volunteers of 18 to 45 years old, under Botswana Network of People Living with HIV/AIDS (BONEPWA), in Gaborone, who disclosed their HIV status. This study was conducted in accordance with the code of Ethics of the World Medical Association (Declaration of Helsinki). Purposive sampling was used to select participants. Only 28 volunteers met the inclusion criteria; 23 females and 5 males. After 6 weeks, one female dropped out of the study.

The participants had to be screened for HIV with the results indicating positive, taking HAART, volunteered to participate in the study and giving blood samples for pre and post measurements of the twelve weeks of aerobic training. With reference to the last CD4 cell count checkup, they had to be of CD4 cell count 350cells/mm^3 and above. They were not supposed to be involved in a structured, monitored training program for at least 6 weeks prior to the beginning of the exercise training. PLWH, but mentally and physically challenged, were excluded. If any participant was unable to provide a signed consent form, she or he did not take part. The pregnant PLWH were also excluded.

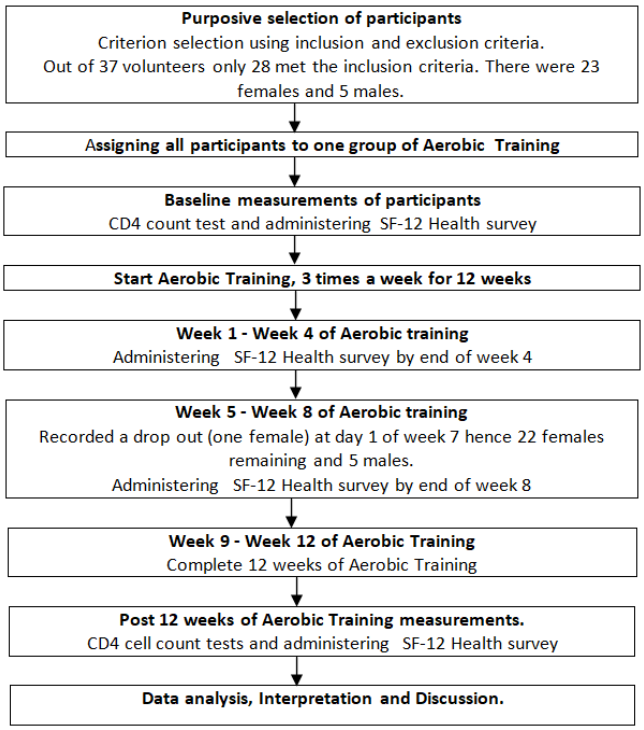

Figure 1. A flow chart showing the research design

Procedure

All the instruments used for data collection were also used during the pilot phase in order to minimize error and ensure reliability.

Self-Reported Short Form 12 Health Survey (SF-12 Health Survey)

The SF-12 health survey is a shortened version of the SF-36 health survey. The SF-12 uses exact eight domains as the SF-36. An SF-12 scoring algorithm is used to carefully score responses yielding two summary measures (Physiodepia, 2023). Those summary measures are the physical component summary (PCS) and the mental component summary (MCS) used as a measure of self-reported HRQoL (Algaralleh et al., 2020). The participants were provided with the self-reported Short Form 12 Health Survey (SF-12 Health Survey) forms to fill while seated. It consisted of 12 questions covering physical and mental health domains. They were each given 3 minutes to complete it. To ensure that the participants understood the instructions for each question and to maintain constancy, the forms were presented in English language and there was a Setswana translated version of the form but all participants preferred the English version. That way, all participants filled and submitted the forms on time.

Blood Pressure Measures

A calibrated automated Omron sphygmomanometer (Omron M3W, Omron healthcare, Japan) was used to measure blood pressure. According to (Hypertension Canada, 2020) the participant sits quietly for 5 minutes on a chair with back support, legs uncrossed, with bare hands supported and kept at heart level. Then a cuff is wrapped firmly around the participant's upper arm at heart level; ensuring to align cuff with brachial artery. The bladder within the cuff had to encircle at least 80% of the upper arm circumference. The researcher pressed the button to quickly inflate the cuff pressure and it automatically stopped when the pressure was appropriate. Then, the systolic blood pressure, and the diastolic blood pressure readings appeared. For each participant, the stable blood pressure measurements were recorded (Hypertension Canada, 2020).

CD4 Cell Count Test

The CD4 cell count flow cytometry was based on whole blood. The participants had to ensure to come in for scheduled blood sample collection in the stipulated date anytime of the day suitable for them from eight o'clock in the morning until half past three in the afternoon. Then, for post-test, they were also encouraged to each continue maintaining pre-test timing. The Phlebotomist had all the blood collection tools needed on a tray within safe and easy-to-reach table for the procedure. The Phlebotomist performed hand hygiene and then wore a safety gown, mask and well fitting, non-sterile gloves. The Phlebotomist introduced herself to each participant and stated her full name and explained the procedure to the participants. She asked the participants of any known allergies or phobias. The Phlebotomist extended the participant's arm and inspected the ante-cubital fossa to locate the vein of a good size that was visible, straight and clear (Center for Disease Control and Prevention [CDC], 2022; Jain et al., 2019). A firm but gentle pressure was applied starting from the center of the venipuncture site and worked downward and outward to cover an area of 2 cm or more with a tourniquet. The located vein site was disinfected and allowed to dry completely for 30 seconds. The participant was asked to form a fist so that the veins would appear more prominent. The vein was anchored by holding the participant's arm and placing a thumb below the venipuncture site. The vein was entered swiftly at a 30-degree angle or less and the needle introduced along the vein at the easiest angle of entry (Jain et al., 2019). Once sufficient blood was collected into the vacutainer tubes, the participant was asked to open his or her fist then the tourniquet was released before withdrawing the needle. The needle was withdrawn gently and gentle pressure applied to the site with clean gauze. The participant was asked to hold the gauze in place; with the arm extended and elevated (CDC, 2022; Jain et al., 2019).

The blood collector tubes were placed in the rack which was later placed in the cooler box for proper transportation from the University of Botswana Biomechanics lab to the Diagnofirm medical laboratory. At the laboratory, the samples were stored at room temperature and were all run within stipulated time frames. Since there are regulations for transporting samples and clinical wastes, all laboratories must establish performance specification for sample transportation as stated by ISO standards (Nybo et al., 2018; World Health Organization [WHO], 2021). The Diagnofirm medical laboratory has standard operational procedures (SOPs) which guide them and inform them on specimen extraction, storage, transportation and disposal. The used needles were placed inside a leak proof and puncture-resistant sharps container. All waste at the laboratory is collected by a contracted registered clinical waste management company.

For CD4 cell count assessment, blood sampled were transferred to tripotassium ethylenediaminetetraacetate (K3-EDTA) bottles for onward analysis of CD4 cell counts by flow cytometry (Beckman Coulter, AQUIOS, Ireland), using monoclonal antibody panel technique (Coetzee & Glencross, 2017). Flow cytometry, according to Nasi et al. (2015) and Bento et al. (2019), is considered the gold standard for CD4 cell count assessment because of its adequacy, accuracy, precision and reproducibility.

Exercise Protocol

Participants were subjected to 12 weeks of aerobic training, three times a week for 60 minutes per session, in the evening from 1730 hours to 1830 hours, at the University of Botswana gymnasium (Table 1). Table 2 presents the target training heart rate (TTHR) and the summarized weekly beats per minute of metronome. The Karvonen method [Target Heart Rate = ((max HR - Resting HR) x % intensity) + Resting HR] was used to determine the training target heart rate (TTHR) for each participant (Luong et al., 2016). Heart rate monitors were used, and these gave a brief insight into the training progress.

Data Analyses

The percentages, means and standard deviations were used for descriptive statistics to summarize socio-demographics of the participants. The significant differences between CD4 cell count and HRQoL variables at baseline and week 12 in the participants were compared using the paired student t-test. The mean was used as the measure of central tendency, and for variability of the data around the mean, the standard deviation was used (Carlson & Winquist, 2018). All analysis was done using IBM statistical package for the social sciences (SPSS) version 24.0 software. The alpha value was set at $p < 0.05$ level of significance.

Results

There were 27 participants, 22 female and 5 male participants who completed all testings. The mean age and standard deviation of participants' ages was 37.78 ± 6.84 years.

Table 3 shows the details of the paired t-test of CD4 cell counts of the participants before and after 12 weeks of aerobic training. The mean and standard deviation of CD4 cell counts before intervention was 763.00 ± 270.85, and after intervention was 766.29 ± 266.79, with a p-value more than 0.05, $p = 0.911$. This shows that there was no statistically significant difference in CD4 cell count after the intervention. The effect size was -0.02, showing a small effect. The results were consistent with the hypothesis; therefore, we fail to reject the null hypothesis.

Table 1

The weekly aerobic training program.

	Duration	Activities
Warm up	10 minutes	Jogging 2 laps around the indoor track or Jogging on the spot for 5 minutes then stretching and breathing exercises.
Day 1	40 minutes	*Body Conditioning Training Day* Jogging 5 laps around the track, shuttle runs (x 8 reps), cardio step activities like: V-steps (x 8 reps both legs), squat (x 8 reps), single leg dead lift (x 8 reps), diagonal hand to toe touch(x 8 reps), side plank with touch (x 8 reps), squat and jump(x 8 reps).
Day 2	40 minutes	*Moderate Intensity Training Day* Shuttle runs (x 8 reps), Sit up and reach toes (x 8 reps), squats (x 8 reps), jog on the spot holding weights on both hands(1kg/2kg) (x 8 reps), push-ups with legs on aerobic steps (x 8 reps), Russian twist with medicine ball (x 8 reps), jog 2 laps around the indoor track.
Day 3	40 minutes	*Cardio Variety Training Day* Aerobic step exercises with free hands, dumbbells (1kg/2kg), overhead dumbbell press in stepping motion(x 8 both sides), barbell split squat (x 8 reps each leg), barbell curl (x 8 reps), dumbbell step up (x 8 reps).
Cool down	10 minutes	Stretching and relaxation activities, walking a lap around the indoor track.

x 8 reps: Eight repetition; Cool down and warm up activities were common on daily basis; Day1, Day2, Day 3: Represent common activities done weekly on first day, second day and third day of the week.

Table 2

The weekly target training heart rate as percentage of maximum heart rate and the beats per minute of the metronome.

Week	TTHR	Metronome (b/min)
1-3	50-55	50-55
4-6	60-65	60-65
7-9	65-70	65-75
10-12	70-75	70-75

TTHR: Training Target Heart Rate; b/min: Beats per minute.

Table 3

Paired t-test analysis of selected health characteristics of PLWH before and after 12 weeks of the aerobic training.

	Pre-tests	Post-test	Mean Difference	*t*	df	d	*p*
	Mean ± SD	Mean ± SD					
CD4 (cells/uL)	763.00 ± 270.85	766.30 ± 266.79	-3.30	-0.113	26	-0.02	0.911

CD4: CD4 count; t: t-value; df: Degree of freedom; d: Effect size (Cohen's d).

Table 4

The analysis of the PCS and MCS measures derived from the SF-12 v1 before and after 12 weeks of the aerobic training.

	Mean ± SD		Mean Difference	t	df	d	*p*
	Pre-training	Post-training					
MCS	78.89 ± 14.33	85.04 ±10.53	-0.615	-2.086	26	-0.40	0.047*
PCS	77.33±14.02	83.19 ±12.35	-5.85	-1.621	26	-0.31	0.117

*MCS: Mental Component Summary; PCS: Physical Component Summary; t: t-value; df: Degree of freedom; d: Effect size (Cohen's d); *: p < .05).*

Table 4 shows the details of the Paired t-test analysis of the physical and mental health component summary measures of participants derived from the SF-12 before and after 12 weeks of aerobic training. The mean and standard deviation of the MCS before intervention was 78.89 ±14.33, and after 12 weeks of intervention was 85.04 ±10.53, with a p-value less than 0.05, p = 0.047. This shows that there was a statistically significant difference in the MCS measures after the twelve weeks of aerobic training intervention. The effect size was -0.4, showing a small effect. The results were not consistent with the hypothesis; therefore, we reject the null hypothesis.

The mean and standard deviation of the PCS before intervention was 77.33 ± 14.02 and after 12 weeks of intervention was 83.19 ±12.35, with a p-value more than 0.05, p =0.117. This shows that there was no statistically significant difference in the PCS measures after the twelve weeks of aerobic training intervention. The effect size was -0.031, showing a small effect. The results were consistent with the hypothesis; therefore, we fail to reject the null hypothesis.

Discussion

The present study supports that there are benefits of aerobic exercise to PLWH. To the best of our knowledge, this is the first study in Botswana that compares pre-post 12 weeks of aerobic training effects on CD4 count and HRQoL of PLWH on HAART under BONEPWA in Gaborone. Out of the 28 participants, only one female participant dropped out leaving 27 participants. That was 3.6% drop-out rate, a very low drop-out rate as compared to other studies. There are some studies that involved PLWH in exercise and they experienced a higher dropout rate when compared to this study (Ibeneme et al., 2022). In their study, Bonato et al. (2017) had 29% dropout rate of participants from the study. The observed dropout rate from the present study may be as a result of the kind of participants we had because, from the onset, they were well informed about the research, they were mature, and probably determined to see whether or not exercise could help their cause. Each time someone was running late for training or missed a session we had to call and hear the reason and kept motivating them to come for training.

Some participants were workers; hence able to come for training most of the time without transport fare problems.

Though there was no statistically significant difference in CD4 cell counts after intervention, the participants had higher CD4 cell count scores as compared to other studies (Table 4). The higher CD4 cell count scores could be attributed to the fact that in Botswana, upon being diagnosed with HIV, one is immediately enrolled for HAART. In their study, Rusmussen et.al (2022) concluded that initiating antiretroviral therapy with a CD4 cell count of equals to or greater than 800 cells/mm^3 compared with 600-700 or 500-599 cells/mm^3 was associated with achieving substantially smaller HIV reservoir on ART. This could be the reason why it was even a challenge to increase the scores to a significant value. All the participants were on HAART and adherence to HAART is associated with higher CD4 cell count and lower viral load (Olivera et al., 2018). Various studies involving PLWHA in exercise suggest the existence of clinical and methodological differences (Ibeneme, 2022). Some studies engaged participants with CD4 cell count that ranged below 300 cells/uL at baseline (Mangona et al., 2015). Some studies experienced significant improvement in CD4 cell counts in the experimental group which could be attributed, somehow, to the lower scores observed at baseline which improves significantly after intervention (Maduagwu et al. 2015).

In 2013, Mendes et al. (2013) reported an increase of CD4 cell counts in both the exercise and control groups after 24 weeks of resistance training with aerobic component. When looking at the fact that the control group did not exercise but had an increase in CD4 cell counts then CD4 cell count increment could be attributed to the adherence to HAART. In attending to weekly lectures in Mendes et al. study, all participants learnt about the importance of adherence to HAART to which they might have taken their therapy seriously. Patients on HAART achieve better immune recovery (Asfaw et al., 2015). Some researchers advocate for the integration of moderate intensity aerobic exercise as an adjunct therapy in management of PLWHA on HAART for greater boost in immune system and improvement in CD4 cell count (Asogwa et al., 2022). The participants of this study were all doing their assigned aerobic exercises, they were all on HAART, and they also volunteered from an organization where there was a strong support system, BONEPWA.

The findings of this study, in relation to the MCS measures, are in line with that of Mbada et al. (2013), who conducted a case control study on HRQoL and physical functioning in PLWH. The study involved 37 PLWH and 37 control group who were not living with HIV. They all completed a self-report SF-12 questionnaire and the MCS of PLWHA in their study was higher than that of the control group.

The PCS measures in this study showed no statistically significant result. Just like our findings, Mbada et al. (2013) found no significant difference in the SF-12 PCS of PLWHA and the control group ($p = 0.782$) in their case-control study of HIV positive and negative participants. In their study, Skogen et al., (2023), reported a poorer HRQoL in PLWHA than in general population. Aerobic training is therefore potentially beneficial to PLWHA in improving some HRQoL domains.

Contrary to our findings, Gomes-Neto et al. (2016), in their cross-sectional study, used the SF-36 to assess the HRQoL. Gomes-Neto et al.'s study objective was to determine if aerobic capacity and health-related quality of life were decreased in HIV positive individuals on HAART. They compared patients with and without lipodystrophy. The domains of SF-36 for patients with lipodystrophy that had lower values were pain, vitality, general health and mental health. When comparing patients with and without lipodystrophy only the SF-36 domain of functional capacity was low in the group with lipodystrophy. The lower values show a reduction in the HRQoL.

This study was not without limitations because it depended on the participants' willingness to take part in the study, being committed to the exercise program and being able to do required testing. The male representation was very low but analysis was done as a group outcome. The investigators did not have control over the medication given to participants. However, they were advised to inquire about the medication and their effects in relation to exercise. The participants were advised that within the 12-weeks of the study they should not do any other exercise program apart from the one in this study.

Conclusion

It can be concluded that PLWHA on HAART can be advised to take part in aerobic exercise training if they wish to obtain significant improvement in MCS. HIV-positive adults should be advised that aerobic training alone would not significantly increase their CD4 cell count. They must always use their HAART medication

as prescribed by their medical practitioners while engaged in aerobic training.

A group of qualified medical experts could in various settings be funded to collaborate with sports scientists to explore the current topic more because, apart from CD4 cell counts and HRQoL, there are other important variables that could be explored like, viral load, duration of being on HAART and the type of drugs prescribed and their effects on an individual; including the type of HIV an individual is grappling with.

Authors' Contribution

Study Design: TM, IUO; Data Collection: TM; Statistical Analysis: TM; Manuscript Preparation: TM, IUO.

Ethical Approval

Ethical clearance was obtained from the University of Botswana Review Board, Ref: UBR/RES/IRB/SOC/GRAD/131 and the Ministry of Health of the Republic of Botswana Research Division Review Board, Ref: HPDME: 13/18/1. Permission to draw pilot study's participants from Greater Gaborone clinics was granted by Ministry of Health Greater Gaborone District Health Management Team (Ministry of Health GGDHMT), Ref: GGDHMT 2/27 V (25) and an approval to draw participants for the major study was from BONEPWA. It was carried out in accordance with the Code of Ethics of the World Medical Association (Declaration of Helsinki).

Acknowledgment

This study is derived from T. Muswere's masters dissertation entitled "Aerobic-Training Effects on Health Characteristics of HIV-Positive Adults under BONEPWA, Gaborone" Supervised by Prof. I. U. Onyewadume. The data collection phase of the Masters dissertation was fully funded by the University of Botswana. The pilot study was self-sponsored. The report on the outcome of the pilot study was separately reported and the participants of the pilot study were not drawn from the same organization as the participants in the major study.

Funding

This research was founded by University of Botswana.

Conflict of Interest

No potential conflict of interest relevant to this study.

References

Algaralleh, A., Altwalbeh, D., & Al-Tarawneh, F. (2020). Health-related quality of life among persons living with HIV/AIDS in Jordan: An exploratory study. *Hiv Aids (Auckl), 12,* 897–907.

Angelo, A. T., & Alemayehu, D. S. (2020). Adherence and its associated factors among adult HIV-infected patients on antiretroviral therapy in south western Ethiopia. *Patient Prefer Adher*, *15,* 299-308.

Asfaw, A., Ali, D., Eticha, T., Alemayehu, A., Alemayehu, M., & Kindeya, F. (2015). CD4 cell count trends after commencement of antiretroviral therapy among HIV-infected patients in Tigray, Northern Ethiopia: A retrospective gross –sectional study. *PLoS One*, 10(3), e0122583.

Asogwa, E.I., Abonyi, O.S., Elom, C.O., Oduma, C.A., Umoke, C.C., Ogai, N.A., Uwaleke, C.C., & Nwimo, I.O. (2022). Comparative effects of 6-weeks progressive resistance exercise and moderate intensity aerobic exercise on CD4 count and weights of people living with HIV/AIDS in Alex-Ekwueme Federal University Teaching Hospital Ebonyi State. *Medicine (Baltimore),* 101(2), e28468).

Avert | Global Information and Education on HIV and AIDS. (2021). *HIV and AIDS in Botswana*. Retrieved from https://www.avert.org/professionals/hiv-around-world/sub-saharan-africa/botswana

Bento, L.C., Correia, R.P., Pedro, E. C., Alexander, A. M., Vaz, A. C., Schimidell, D., Barroso, R. S., & Bacal, N. S., (2019). Aquios CL flow cytometer performance in automated quantification of lymphocyte subpopulations. *J Bras Patol Med Lab*, *55*(4), 378-389.

Bonato, M., Galli, L., Passeri, L., Longo, V., Pavei, G., Bossolasco, S., Bertocchi, C., Cernuschi, M., Balconi, G., Merati, G., Lazzarin, A., La Torre, A., & Cinque, P. (2017). A pilot study of brisk walking in sedentary combination antiretroviral treatment (cART) treated patients: benefit on soluble and cell inflammatory markers. *BMC Infct Dis*, *17*(1), 61.

Carlson, K. A., & Winquist, J. R. (2018). *An introduction to statistics: An active learning approach* (2nd ed.). London, United Kindom: SAGE Publication.

Chisati, E. M., & Vasseljen, O. (2015). Aerobic endurance in HIV-positive young adults and HIV-negative controls in Malawi. *Malawi Med J*, *27*(1), 5–9.

Coetzee, L. M., & Glencross, D. K. (2017). Performance verification of newly fully automated Aquios flow cytometry PanLeucogate (PLG) platform for CD4-T-lymphocyte enumeration in South Africa. *PLoS One*, *12*(11), e0187456.

Creswell, J.W. (2015). *A concise introduction to mixed methods research*. London: SAGE Publications Inc.

Global AIDS monitoring. (2020.) *Country progress report-Botswana*. Retrieved from Unaids.org/sites/default/files/country/documents/BWA_2020_countryreport.pdf

Gomes-Neto, M, Conceicao, C. S., Ogalha, C., & Brites, C. (2016). Aerobic capacity and health-related quality of life in adult HIV-infected patients with and without lipodystrophy. *Braz J Infect Dis, 20*(1), 76-80.

Hypertension Canada. (2020). *2020-2022 hypertension highlights*. Retrieved from https://hypertension.ca/wp-content/uploads/2020/10/2020-22-HT-Guidelines-E-WEB_v3b.pdf

Ibeneme, S, C., Uwakwe, V. C., Myezwa, H., Irem, F. O., Ezenwankwo, F. E., Ajidahun, T. A., Ezuma, A.D., Okonkwo, U. P., & Fortwenge, G. (2022). Impact of exercise training on symptoms of depression, physical activity level and social participation in people living with HIV/AIDS: a systematic review and meta-analysis. *BMC Infect Dis, 22*, 469.

Jain, S., Chraiti, M-N., Pittet, D., & Mclaws M-L. (2019). Blood collection guidelines for inpatients and outpatients,

home-basedcare and long-term care facilities. *J Hosp Infect*, *104*(4), 600-602.

Laher, A. E., Richards, G. A., Paruk, F., & Venter, W. D. F. (2021). Antiretroviral therapy non-adherence among HIV-positive patients presenting to an emergency department in Johannesburg, South Africa: Associations and reasons. *S Afr Med J, 111*(8), 753-758.

Luong, M.W., Ignaszewski, M., & Taylor, C. M. (2016). Stress testing: A contribution from Dr Robert A. Bruce, father of exercise cardiology. *BC Med J*, *58*(2), 70-79.

Maduagwu, S. M., Kaidal, A., Gashau, W., Balami. A., Ojiakor, A. C., Denue, B. A., & Kida, I. (2015). Effects of aerobic exercise on CD4 cell count and lipid profile of HIV infected persons in North Eastern Nigeria. *J AIDS Clin Res*, *6*(10), 508.

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

Mbada, C. E., Onayemi, O., Ogunmoyole, Y., Johnson, O. E., & Akosile, C. O. (2013). Health related quality of life and physical functioning in people living with HIV/AIDS: A case control design. *Health Qual Life Outcomes*, 11, 106.

Mendes, E. L., Andaki, A. C. R., Amorim, P. R. S., Natali, A. J., Brito, C. J., & De Paula, S. O. (2013). Physical training for HIV positive individuals submitted to HAART: Effects on anthropometric and functional parameters. *Rev Bras Med Esporte*, *19*(1), 16-21.

Nybo, M., Cadamuro, J., Cornes, M. P., Gómez Rioja, R., & Grankvist, K. (2018). Sample transportation - an overview. *Diagnosis*, *6*(1), 39-43.

Olivera, L. S., Caixeta, L. M., Martin, J. L. R., Segati, K. D., Moura, R. S., Daher, M. C., & Pinto, E.M. H. (2018). Adherence to antiretroviral therapy and correlation with adverse effects and coinfectios in people living with HIV/AIDS in the municipality of Goias state. *Rev Soc Bras Med Trop*, *51*(4), 43644.

Pantazis, N., Paparizos, V., Papastamopoulos, V., Metallidis, S., Antoniadou, A., Adamis, G., Psichgiou, M., Chini, M., Samabatakou, H., Chrysos, G., Sispas, N., Gogos, C., Barbunakis, E., Panagopoulos, P., Katsarou, O., & Touloumi, G. (2023). Low pre-ART CD4 count is associated with increased risk of clinical progression or death even after reaching 500 CD4 cells/μL on ART. *PLoS One, 18*(3), e0283648.

Physiopedia. (2023). 12-Item Short Form Survey (SF-12). Retrieved from https://www.physio-pedia.com/12-Item_Short_Form_Survey_(SF-12)#citation

Ramogola-Masire, D., Poku, O., Mazhani, L., Ndwapi, N., Misra, N., Arscott-Mills, T., Blank, L., Ho-Foster, A., Becker, T. D., & Yang, L. (2020). Botswana's HIV response: Policies, context, and future directions. *J Community Psychol,* 48(3), 1066–1070.

Rusmussen, T. A., Ahuja, S. K., Kuwanda, L., Vjecha, M. J., hudson, F., Lal, L., Rhodes, A., Chang, J., Palmer, S., Auberson-Munderi, P., Mugwerwa, H., Wood, R., Badal-Faesen, S., Pillay, S., Mngqibisa, R., LaRosa, A., Hildago, J., Petoumenos, K., Chiu, C., Lutaakome, J., Kitonsa, J., Kabaswaga, E., Pala, P., Ganoza, C., Fisher, K., Chang, C., Lewin, S. R., & Wright, E. J. (2022). Antiretroviral initiation at ≥800 CD4+ Cells/mm^{3} associated with lower humman immunodeficiency virus Reservoir size. *Clin Infect Dis*, *75*(10), 1781–1791.

Skogen, V., Rohde, G. E., Langseth, R., Rysstad, O., Sørlie, T., & Lie, B. (2023). Factors associated with health-related quality of life in people living with HIV in Norway. *Health Qual Life Outcomes, 21,* 14.

Taye, Y. (2016). Intervention of floor aerobics exercise on hematological characteristics of people living with HIV/AIDS, the case of Yeterssfa Bisrat. *Miskir Assossiation, Dire Dawa, Ethiopia*, *5*(4), 32-40.

United Nations Program on HIV/AIDS. (UNAIDS, 2019). *Botswana extends free HIV treatment to non-citizens*. Retrieved from Unaids.org/en/keywords/Botswana.

United States Presidential Emergency Plan for AIDS Relief. (USPEPFAR, 2018). *Botswana country operational plan 2018 Strategic direction summary*. Retrieved from copsdata.amfar.org/SDS/2018/Botswana.pdf

United States Presidential Emergency Plan for AIDS Relief. (USPEPFAR, 2019). *Botswana country operational plan 2018 Strategic direction summary*. Retrieved from copsdata.amfar.org/SDS/2019/Botswana.pdf

United States Presidential Emergency Plan for AIDS Relief. (USPEPFAR, 2020). *Botswana country operational plan COP20: Strategic direction summary*. Retrieved from https://www.state.gov/wp-content/uploads/2020/07/COP-2020-Botswana-SDS-FINAL.pdf

United States Presidential Emergency Plan for AIDS Relief. (USPEPFAR, 2022). *Botswana country operational plan (COP/ROP) 2022 Strategic direction summary SDS*. Retrieved from state.gov/wp-content/uploads/2022/09/Botswana-COP22-SDS.pdf

World Health Organization. (WHO, 2021). *Guidance on regulations for the transport of infectious substances 2021-2022*. Retrieved from https://iris.who.int/bitstream/handle/10665/339825/9789240019720-eng.pdf?sequence=1