OPEN ACCESS
Advances in Health and Exercise

REVIEW ARTICLE

Effects of aerobic exercise on health outcomes and quality of health in people living with HIV on antiretroviral therapy

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Received:
06 March , 2025

Accepted:
May 18, 2025

Online Published:
May 18, 2025

Keywords:
Aerobic exercise, HIV, quality of life, Uganda.

Abstract

HIV remains a global major public health issue and the cases in developing countries are so high. Antiretroviral Therapy (ART) plays a big role in reducing the morbidity and mortality among the people living with HIV (PLHIV). The ART is associated with long-term side effects including an increased risk of Non-Communicable Diseases (NCDs) such as cardiovascular disease, diabetes, and metabolic syndrome. These complications negatively impact the quality of life of PLHIV, necessitating holistic approaches to care. While ART controls viral replication, complementary strategies, including lifestyle interventions like exercise, are essential to mitigate NCDs. Exercise, particularly aerobic and resistance training, has been shown to improve cardiovascular health, metabolic function, and psychological well-being in PLHIV. Specific exercises such as walking, jogging, cycling, swimming, and weight training can help manage NCDs effectively when tailored to an individual's fitness level and health needs. Supervised exercise programs, led by professionals such as clinical exercise physiologists, are critical to ensure safety, optimize benefits, and encourage adherence. These programs could be integrated into HIV care to provide structured and effective interventions. In limited resource countries, access to exercise facilities, and a lack of trained professionals present significant barriers to implementing exercise programs for PLHIV. Additionally, cultural misconceptions and a lack of awareness about the role of exercise in health management hinder uptake. However, from the reviewed papers, research gaps exist regarding context-specific exercise protocols, the long-term benefits of supervised exercise, and how to best implement these programs in resource-limited settings. In conclusion, structured exercise programs hold great potential to improve health outcomes and quality of life for PLHIV on ART. Addressing existing barriers and conducting further research are essential to maximize the impact of exercise as a tool for managing NCDs in this population.

Introduction

There have been significant changes in the quality of human life since Acquired Immune Deficiency Syndrome (AIDS) was first declared in humans in 1981 (Okoroiwu et al., 2022). Bailes et al. (2011) states that the Human Immunodeficiency Virus (HIV), a retrovirus belonging to the Lentivirus genus, is the cause of the sickness. The virus slowly affects a human body and deprives it of its immunity by seeking to destroy Clusters of Differentiation 4 (CD4) cells gradually - a type of T-lymphocytes (T-cells) that is critical to the immune system. According to O'Brien et al. (2016), there is a higher chance of opportunistic infections, which can reduce one's functional work capacity and have other psychological impacts, when the immune system is significantly compromised.

In 2020, the United Nations Programme on HIV & AIDS [UNAIDS] released a report stating that HIV is one of the most serious public health issues facing the world today (UNAIDS, 2020). Of the approximately 37.9 million people living with HIV/AIDS worldwide in 2019, 95.5% were adults and 4.5% were children under the age of 15 years. An estimate of 1.7 million individuals worldwide

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To Cite: Nicholas, M., Milton, C., Lumbuye, L., Elyvania, N., & Loyce, N. (2025). Effects of aerobic exercise on health outcomes and quality of health in people living with HIV on antiretroviral therapy. *Adv Health Exerc*, 5(1), 40-52.

became newly infected with the virus in 2018 and 94% of these were aged 15 years and above. Africa was the most affected with 25.7 million people living with HIV hence making Africa to account for about two thirds of the global total of new infections in 2018 with about 1.1 million infected (Velavan et al., 2021). In 2021, there were about 1.5 million new infections in the world with the highest infections recorded from Africa (UNAIDS, 2021). According to a UNAIDS (2022) report, over 2.5 million people have died due to AIDS and more than 1.5 million people live with HIV infection in Uganda alone.

People living with HIV (PLHIV) frequently suffer from mental illnesses, yet these conditions are frequently ignored and neglected (Ministry of Health (MoH), 2018). This situation was worsened by COVID-19 pandemic that disrupted the already imperfect mental health services, (Hong et al., 2023). They also suffer from psychological disorders, injury from infection, treatment toxicity, and associated comorbidities (Althoff et al., 2016).

The quality of life and life expectancy of those afflicted with HIV have been greatly enhanced by scientific advances in therapy and attempts to expand these medicines. For example, Anti-retroviral Therapy (ART) such as the Highly Active Antiretroviral Therapy (HAART) have reduced hospitalization rates, lowered mortality, and generally improved patients' quality of life (Bopp et al., 2003). On the other hand, a number of negative side effects are also linked to this treatment, including exhaustion, nausea, pain, anxiety, sadness, a decrease in functional work ability, and low energy (Ibeneme et al., 2022). Therefore, there is still need for multi-sectoral approaches to reduce these side effects and prevent other infections that would increase pill burden and affect the adherence to ART. Other strategies that control the effect of the virus and increase public attention is needed (Uganda AIDS Commission, 2011). Treatment of HIV involves regular visits to the hospital mainly when unstable, that is; when one has low CD4 count 200 copies and below, high viral load and any other opportunistic infection. It is estimated that about 254,000/= to 524,000/= is spent on adults and 186,900/= to 190,000/= is spent on children in Uganda monthly (Moreland et al., 2013). This cost may be higher, depending on where they get their treatment and other comorbidities. Moreover, many PLHIV travel long distances to get services where they are least known this also increases the cost of care.

Aerobic exercise is currently being explored as a means of dealing with symptoms, complications, and unwanted side effects that reduce the quality of life for chronic HIV infection (McIntyre et al., 2020). Aerobic exercise may be a helpful treatment for a variety of ART side effects and symptoms, according to studies from both healthy individuals and those with various chronic illnesses (O'Brien et al., 2016). Therefore, aerobic exercise is now recommended by studies as one of the requirements in managing HIV positive clients. According to O'Brien et al. (2016), exercise therapy should start as soon as possible after an HIV infection diagnosis in an effort to postpone the onset of symptoms, lessen the severity of existing symptoms, and possibly postpone the progression of the disease and the subsequent onset of Non-Communicable Diseases (NCDs).

According to Okechukwu et al. (2022) aerobic exercise is a low- to moderate-intensity physical activity that uses oxygen in the metabolic processes to produce energy during exercise. Patients can engage in these activities for prolonged periods of time.

Nystoriak & Bhatnagar (2018) further explained that regular aerobic exercise has several health benefits, including: strengthening muscles, improving circulation efficiency by strengthening heart muscle, and reducing blood pressure. These workouts also contribute to the body's overall red blood cell count, which facilitates oxygen delivery, lowers stress levels, decreases the risk of depression, and improves cognitive function (Bopp et al., 2003). O'Brien et al. (2016) in a study on the benefits of aerobic exercise for persons living with HIV/AIDS showed improvements in their health, mood, life satisfaction, and quality of life in addition to symptoms of anxiety and sadness.

According to a study, aerobic exercise raises CD4 and quality of life in HIV-positive people in Nigeria the experimental group improved by 36.9% while the control group improved by 6.8 (Ezema et al., 2014). Research also revealed that exercise increased CD4 counts in HIV patients receiving antiretroviral therapy by 107.5% (Maduagwu et al., 2017). People living with HIV (PLHIV) on ART get a greater increase in CD4 cell counts with appropriate exercises compared to non-exercising counterparts (Dang et al., 2018). In Uganda a study showed an increase of 29.7% (Nicholas et al., 2024a).

People living with HIV have also been reported to be overweight/obese with hypercholesteremia, and this is linked to an emergency NCDS that lowers their quality of life, (Moyo-Chilufya et al., 2023). Krupa et al. (2012) revealed that several characteristics were important indications of obesity/overweight, including older age, female sex, early stage of the illness, lower CD4 level, and mild to moderate physical activity. It was noted that as part of standard HIV therapy, clinicians should take into account implementing targeted weight management programs and be cognizant of the health consequences associated with obesity (Krupa et al., 2012). PLWHIV are more likely to suffer from depression and non-communicable diseases, according to the document, which also suggests aerobic exercise as a treatment and prevention measure (Consolidated guidelines for prevention and treatment of HIV in Uganda, 2016). In order to prevent non-communicable diseases, the guidelines advocate lifestyle changes. This is the first line of defense against and management for non-communicable diseases including diabetes, mental health and hypertension. Additionally, it is recommended that they engage in aerobic activities for at least half an hour per day, five days a week. It continues by stating that aerobic activity lowers blood pressure by an average of 4 mmHg in the systolic and 3 mmHg in the diastolic, which will subsequently improve quality of life, regardless of whether a person has hypertension. According to the Consolidated Guidelines for Prevention and Treatment of HIV in Uganda (2016), health care providers are also advised to assist patients in finding enjoyable activities because this improves adherence to the exercise regimen. The precise aerobic workouts that should be performed and their advantages are not sufficiently explained, though. Furthermore, exercise is not listed as one of the best strategies to prevent and treat depression in the guidelines.

Therefore, the purpose of this review paper is to provide more details about the advantages of aerobic exercise for people living with HIV who are on ART, as well as the kinds of exercises that they should perform and the strategies that should be modified to guarantee exercise compliance. The essay backs up its suggestions with data from both industrialized and developing nations. The information will be useful to clinicians and encourage the use of physical activity in the prevention and management of depression and non-communicable diseases in PLWHIV.

Methods

The literature search technique involved searching for peer-reviewed research articles, theses, reports, and pertinent grey literature in reputable academic databases including PubMed, Google Scholar Scopus, and other online publications. every study and review that examined the effects of aerobic exercise and other forms of exercise intervention on the health and well-being of people living with HIV. These comprised program assessment studies as well as qualitative and quantitative research. Excluded from consideration were studies that did not emphasize the positive effects of exercise on health and quality of life.

Selection and Screening of Studies

After the search, abstracts and titles were examined to determine the relevancy of the publications. The publications were also assessed for dependability. The next step was the text review, in which selected articles were checked to ensure they met the standards. For clarity, the review's primary conclusions were condensed into the subthemes.

HIV and the Efforts to Manage it a Case of Uganda

Uganda as many other developing countries has been heavily heat by HIV, for example, an estimated 23,000 persons in Uganda lost their lives to AIDS-related causes in 2018, while an estimated 1.4 million people were living with HIV. The estimated prevalence of HIV in adults (ages 15 to 49) was 5.7% as of 2018. With 8.8% of adult women living with HIV compared to 4.3% of men, women were disproportionately affected. About 1.5 million new infections occurred worldwide in 2021; seven of the ten countries with the highest infection rates were in Africa, including Uganda (UNAIDS, 2021).

Commercial sex workers, young girls and teenage women, and members of Uganda's transitory fishing communities are among the other groups most impacted by HIV in Uganda (UNAIDS, 2017). Antiretroviral therapy (ART) has been incorporated into the Uganda AIDS Control Program's comprehensive approach to HIV prevention, care, and treatment within the last ten years. Consolidated guidelines for prevention and treatment of HIV in Uganda (2016) emphasize initiatives that will end

AIDS by 2030 and control the HIV epidemic by 2020. However, given that new infections are still occurring as of January 2022, this might not be the case (DHIS2, Jan 2022).

Table 1
Overview of the reviewed sources.

Authors	Country	Purpose	Type of source	Summary points
Nicolson et al. (2017)	Australia	To evaluate interventions aimed at increasing adherence to exercise increase.	A systematic review and meta-analysis	Behavioural counselling, action coping plans and/or audio/video exercise cues did not improve adherence significantly.
Argent et al. (2018)	Ireland	To discuss reasons why patients may not adhere to a prescribed exercise program.	Journal article	highlights how well-designed connected health technologies, such as the use of mobile devices.
Galaviz et al. (2018)	USA	To summarize the literature around lifestyle diabetes prevention programs and provide recommendations for prevention strategies in clinical practice.	Review article	There was evidence that supports the efficacy & effectiveness of lifestyle diabetes prevention for implementers (eg, clinicians, community members).
Jones et al. (2021)	UK	Personalised and targeted exercise interventions are beneficial for ageing and the management of chronic and complex conditions.	A call to action	Personalised exercise were found to be beneficial.
Chang et al. (2013)	Taiwan	To systematically record the daily life journal on a platform to increase the self-awareness and improve the sedentary lifestyle and to assist clinicians in understanding and facilitating patients.	Clinical pilot study	Persuading people to improve their activities during non-working hours can enhance the general physical activity.
Nicholas et al. (2024a)	Uganda	To assess the effects of aerobic exercise training on immunological markers.	Quantitative study	There was a marked improvement in immunological markers in the participants.
O'Brien et al. (2016)	Canada	To examine the safety and effectiveness of aerobic exercise interventions in adults living with HIV.	systematic review and meta-analysis	Moderate intensity aerobic exercise was found to be safe and effective in HIV positive clients
Pearce & Longhurst (2021)	New Zealand	To evidence the effectiveness of CEPs in Noncommunicable Disease (NCD) rehabilitation	Journal article	Exercise Physiologists can play a role in reducing chronic disease cost if given opportunity.
Soan et al. (2014)	Australia	The existing role of accredited exercise physiologists in interprofessional practice is examined	Journal article	Exercise physiologists in professional practice were found to be very important in promoting exercise.

It is significant to highlight that since 2013, the number of Ugandans living with HIV who are obtaining ART has gradually increased. In that year, the nation hit a tipping point where fewer new infections occurred annually than the number of persons starting antiretroviral therapy. There were 1.5 million HIV-positive individuals by 2019. According to the Uganda AIDS Commission (2020), 85% of people are receiving HIV treatment, 5.8% are adults aged 15–49, and 53,000 new infections occur.

Side Effects of ART in PLWHIV

A healthy life is not guaranteed by ART alone, as WHO reported in 2019 that, HIV patients on ART are more likely to develop non-communicable diseases. People on ARVs are more likely to be obese and to suffer from related non-communicable diseases since the medications increase the body's susceptibility to other illnesses including diabetes and cancer.

It has been demonstrated that ARVs cause metabolic alterations in PLWHA (those living with HIVAIDS). These alterations include reduced aerobic capacity, lipodystrophy (possibly due to protease inhibitors), central fat accumulation, and hyperlipidemia. These are risk factors for non-communicable diseases such as depression, cancer, diabetes, and high blood pressure. As previously mentioned, one of the best mitigating factors has been proven to be aerobic exercise. According to Vaillant & (2023), PLWHIV on ART have also shown significant changes in the pathophysiology of HIV illness and symptomatology of infection. These individuals no longer have high rates of opportunistic infections linked to AIDS or muscular atrophy. At this point, the symptomatology has gone in the exact other direction. Since the first new diagnosis, the life expectancy of PLWHA has almost tripled due to the efficacy of ART. As a result, we have started to see PLWHA for several decades after they reach adulthood. However, PLWHA have started to exhibit higher rates of metabolic abnormalities, such as high body mass index (BMI) as a result of the harmful side effects of ART medications and the long-term effects of viral infection. Extremely elevated cholesterol levels can cause disability and death, as well as pancreatitis and associated cardiovascular illnesses (Naylor et al., 2019).

The virus itself, the associated drugs, or a mix of the two can cause a range of psychological and physical symptoms in people living with HIV/AIDS. The general well-being and overall quality of life are frequently diminished due to the type of concurrent symptoms that are encountered frequently (Oguntibeju, 2012). There is also a correlation between the frequency of reported symptoms and increased psychological distress, anxiety, depression, impaired functional job ability, poor adherence to pharmaceutical treatment, and self-medication. Adults with HIV are more prone than those without HIV to develop diabetic mellitus (DM) due to the higher prevalence of chronic metabolic problems brought on by both the HIV infection and antiretroviral therapy (ART). Research indicates that within four years, up to 10% of HIV-positive patients using ART go on to acquire diabetes mellitus (Consolidated guidelines for prevention and treatment of HIV in Uganda, 2016). The primary factor contributing to the development of DM in PLHIV is antiretroviral medications. Protease inhibitors like lopinavir and ritonavir result in lipodystrophy, decreased adipocyte differentiation, impaired glucose transporter type 4 translocation, decreased insulin production, and dyslipidemia with lipotoxicity, all of which contribute to insulin resistance, this will lower their quality of life (Talwani et al., 2011). PLHIV are susceptible to neurological and psychiatric illnesses. Major depression affects 10–20% of those living with HIV. PLHIV with depression may have poor treatment outcome and are less likely to attain adequate ART adherence. An essential component of HIV care programs should include the assessment and management of depression (Truong, 2021).

Use of Exercise in the Management of Non-communicable Diseases in PLHIV on ART

Maintaining physical activity is essential for preventing potential pharmacological side effects, enhancing wellbeing, and enhancing quality of life (Larson, 2021). Since regular exercise has been demonstrated to increase bodily strength, lower the risk of obesity and non-communicable illnesses, strengthen immunity, and enhance quality of life, patients on ARVs are urged to exercise (Jaggers & Hand, 2014). Health workers should therefore reinforce lifestyle modification interventions at every clinic visit.

Many people living with HIV have environmental and personal factors that make them more likely to be obese and have high visceral fat mass. The

medical community is currently looking for different approaches to managing and preventing these issues. Exercise at a moderate level enhances muscular strength, functional ability, overall health, and quality of life while also improving body composition, psychological well-being, and total cholesterol (O'Brien et al., 2016).

A research by Roubenoff & Virginia (2001) indicated that three weekly strength-training workouts enhanced one repetition maximum by 31% to 50% in 8 weeks, demonstrating that progressive resistance training leads to gains in muscle strength and muscular hypertrophy. More significantly, after eight more weeks of self-selected exercise, gains in muscle strength were mostly sustained, according to Trusts (2020). Numerous clinical groups and general populations have been shown to benefit from aerobic and resistance exercise, according to long-term studies like the Framingham Heart Study and the Aerobics Center Longitudinal Study, among others. Several studies suggest that PLWHA can experience comparable effects within 6 weeks of a recommended physical activity intervention, despite its shorter length (Jaggers & Hand, 2014).

Nicholas et al. (2024a) claims that moderate-intensity aerobic and weight training raised CD4 cell counts afterward and that PLWHA can safely engage in this type of exercise. The author continued by saying that by stimulating other immune cell populations, this increase in CD4+ cells typically improves resistance to infection. It is challenging to compare this study with previous HIV-related exercise studies, nevertheless, due to a number of limitations. Inmates who had served time in prison and were now receiving methadone therapy for opioid addiction, for instance, made up their participant pool. The fact that just one of their participants was now on a stable ART regimen, which would have predicted that their viral load and CD4+ cell counts would be unstable, is another significant constraint (Trusts, 2020).

In contrast to the control group, which showed a notable decline in CD4+ cell counts, Warburton, et al., (2006) observed a steady CD4+ cell count with exercise during a 12-week intervention (45–60 minutes, three times/week). According to Pedro et al. (2024), structured resistance exercise also causes a particular immune response in PLWHA. They showed that doing resistance exercise three times a week for 12 weeks increases the number of CD4+ and CD8+ cells, which in turn improves the immune system's integrity. Additionally, following a 12-week progressive resistance exercise (60 minutes, three times a week) intervention, Ibeneme et al. (2019) showed improvements in quality of life (QoL), a significant improvement in functional capacity, and an increase in the CD4+ cell count in PLWHA.

Meanwhile, strength training three times a week for 12 weeks resulted in a considerable increase in maximum muscular strength and bone mineral density (BMD) (Ibeneme et al., 2019). However, its physiological and therapeutic benefits on the immune system, bone mineral density (BMD), and quality of life (Qol) in this population can only be ascertained by examining the distinct influence of physical exercise through pertinent studies in PLWHA.

Research by Nicholas et al. (2024c) suggests that regular exercise can help reduce anxiety and depression by: releasing feel-good endorphins, endogenous cannabinoids, which are natural chemicals that resemble cannabis and can improve your mood and diverting your attention from concerns in order to escape the vicious cycle of pessimistic thinking that fuels anxiety and sadness. Frequent exercise also provides numerous emotional and psychological advantages. It can assist you be more self-assured. Reaching even modest fitness objectives or difficulties can increase your confidence.

Weight loss: People with HIV should be counseled to maintain a healthy weight by getting enough exercise, and those who are overweight should be counselled to limit their consumption of high-calorie foods. Losing weight is a significant lifestyle change that lowers the risk of diabetes and high blood pressure. A 4.5 kg weight loss can assist lower blood pressure or avoid hypertension. Systolic blood pressure can drop by 5 to 20 mmHg with a weight loss of about 9 kg.

Increased insulin sensitivity, glucose control, and β-cell function have all been associated with moderate-to-intense physical activity. Programs that combine nutrition and exercise reduce the prevalence of diabetes and improve cardiometabolic risk factors in high-risk individuals. In people with impaired glucose tolerance, it also aids in lowering impaired fasting glycaemia (IFG) and 2-hour post-load glucose levels. According to Galaviz et al.

(2018), lifestyle modifications can help reverse the effects of genes on diabetes risk and encourage the regression of pre-diabetes to normoglycemia. Those with HIV who are on ART may also benefit from these advantages.

According to Nystoriak & Bhatnagar, (2018) regular aerobic exercise has a number of health benefits, such as enhancing circulation efficiency and lowering blood pressure by strengthening and growing the heart muscle. According to Hossain et al. (2024), this type of exercise also decreases stress, lowers the incidence of depression, increases the body's total red blood cell count, facilitates oxygen delivery, and improves cognitive function. Additionally, moderate exercise helps people with HIV function better in their cardiovascular and nervous systems. People with HIV who engage in moderate exercise at least three times a week for 30 to 45 minutes each session over ten weeks see significant improvements in their blood circulation and nervous system (Odunitan-Wayas, 2018).

It should be noted that both healthy individuals and those with various chronic illnesses, aerobic exercise may be a useful treatment for a variety of ART side effects and symptoms (O'Brien et al., 2016). Physical activities such as brisk walking, swimming, running, or cycling are crucial for improving cardiovascular fitness, lowering the risk of heart disease, lowering blood pressure, increasing HDL, or "good," cholesterol, improving blood sugar regulation, helping with weight management and/or weight loss, improving lung function, and lowering resting heart rate. This is because the muscles used in exercise provide a significant amount of energy by combining glucose and oxygen (Chertoff et al., 2020).

People with many illnesses, including HIV, can benefit from aerobic fitness since it keeps their muscles from deteriorating. Cytokine control is one of the other benefits of exercise, according to research on autoimmune illnesses like multiple sclerosis. One kind of rehabilitation technique that can be utilized to treat impairment, such as diminished cardiovascular fitness and strength in people with HIV, is aerobic exercise. People with viruses may also benefit from exercise because it has been linked to both disease prevention and health promotion (Martin et al., 2009). Additionally, aerobic exercise deserves consideration due to its relationship to body image, which has been demonstrated to be significant in some HIV-affected populations (O'Brien et al., 2016).

Significant improvements in cardiorespiratory wellness, quality, and bodily and mental health can be achieved by engaging in steady or intermittent oxygen-consuming exercise, or by combining dynamic resistive exercise with steady high-impact exercise (Treston, 2019).

It has been demonstrated that, in comparison to a sedentary lifestyle, structured and supervised physical exercise at varying intensities and duration improves PLWHA's physical, mental, and immune systems. When moderately intense aerobic exercise was performed for 16 weeks (30 minutes, three times per week), the CD4+ cell count either grew or remained steady, improving resistance to infection (Biddle et al., 2019). In order to address disability, weakened immunity, and to maintain or enhance the health of individuals living with HIV, both individuals and rehabilitation professionals have used exercise as a technique (Quigley et al., 2019).

It is worth mentioning that longer periods of high-intensity exercise, or overtraining, have been shown to worsen infections, impair human immune function, and raise mortality in animal models. Despite evidence that moderate-intensity exercise can improve immune measures, reduce HIV infection symptoms, and affect neutrophil proliferation, epinephrine and cortisol secretion, a temporary decrease in lymphocyte levels, an increase in natural killer cells, and cytokine levels (IL-1, TNF-α, IL-6), many doctors continue to advise their HIV-positive patients to avoid physical exertion for these reasons (Bopp et al., 2003). After just one exercise session, this reaction is reduced in HIV-positive people. Higher intensity exercise reduces immune system efficacy, increasing the risk of opportunistic infections in those without HIV (Campbell & Turner, 2018). Because of this, people with HIV have often been advised to engage in moderate-intensity activity rather than high-intensity exercise.

A population undergoing cardiac rehabilitation showed comparable results, with participants' ability to perform activities of daily living improving by 40%. However, the effects of this increase in functional capacity have not been assessed in an HIV-infected population (Hossain et al., 2024). If this link is present in an HIV-positive population, then greater functional capability may reduce HIV-

related impairment and enable longer periods of independent living.

Specific Exercises that Could Be Used to Effectively Management Non-Communicable Diseases in Uganda.

Developing countries like Uganda, are registering rising epidemics of non-communicable diseases (NCDs) such as hypertension, diabetes, and cardiovascular conditions which are becoming a crucial public health challenge. Effective treatment of these NCDs helps to improve quality of life as well as decrease healthcare expenses both in HIV positive and negative people. One of the promising approaches towards the management of NCDs is the use of regular physical activity. Physical exercise has been widely known to lower the risk factors for NCDs such as obesity, high blood pressure, and cardiovascular diseases (World Health Organization [WHO], 2020). Numerous exercise interventions have been effective in helping populations manage these diseases, particularly when tailored to the local context and available resources like exercise without equipment. The workout will consist of brisk walking, jogging, free kicks (kick in front while raising the heal back), knee lifts (lift knees alternately while raising your hands up), jumping jacks, circuit training, and aerobic dance at a moderate intensity at a tempo of 120-150 mbp ensuring the principle of progressive progression. These activities can be performed at least five times a week under supervision for at least 30 minutes, or three times a week for at least 50 minutes to increase the weekly exercise total to 150 minutes (Physical activity guidelines for Americans, 20218). Every session will start with a 5-minute warm-up, followed by stretching, at least 25 minutes of exercise, and a 5-minute cool-down with relaxation exercises. The ACSM guidelines can also be followed for all forms of exercise training (Colberg et al., 2016). Nicholas et al., 2024a used a program that included brisk walking, jogging, and aerobic dancing for 30 minutes, five days a week, at moderate intensity with uplifting music. The exercise sessions progressed as follows: Week 1--2: Tempo of 120 BPM (beats per minute). Week 3--4: Tempo of 130 BPM. Week 5--6: Tempo of 140 BPM. Week 7--12: Tempo of 150 BPM. Each session consisted of: A 5-minute warm-up followed by stretching. At least 25 minutes of aerobic activity. A 5-minute cool-down with relaxation activities. This proved to be very usefull in improving the quality of health of HIV positive patients on ART.

Ways to Improve Adherence to Exercise by PLWHIV on ART

Adherence to an exercise regime is as crucial as a part of the health care of persons living with HIV (PLWHIV), particularly those on antiretroviral therapy (ART). Exercise has been reported to improve immune function, physical and mental health, as well as reduce the long-term side effects of HIV and ART (Naylor et al., 2019; Nicholas et al., 2024b). However, routine exercise adherence might be challenging for PLWHIV due to factors such as fatigue, psychosocial factors, and social determinants of health. Therefore, understanding and controlling the determinants of exercise adherence is important to maximize the benefits of physical activity in this population. Interventions such as individualized exercise programs, social support, and addressing mental health problems have been shown to improve exercise adherence in PLWHIV on ART. Evidence suggests that unsupervised and individual exercises which are typically prescribed by clinicians are linked to poor adherence. This can be the cause of low exercise compliance (Bannell et al., 2023). Only 35.0% of patients in a short-term trial of patients with nonspecific low back pain were found to be highly adherent to at-home exercises. According to patient self-report, 50.8% of participants in this study who were given a customized exercise program showed non/low adherence throughout the whole rehabilitation regimen. However, there is no well-established category to which adherence may be classified as poor, and the term "non/low adherence" is used inconsistently throughout the research. Thus, he came to the conclusion that patients' exercise compliance was inadequate (Argent et al., 2018).

Increasing compliance with exercises in persons, particularly those with chronic conditions like HIV, requires complex interventions aimed at addressing physical and psychological barriers. Individualized exercise programs, motivational interviewing, and the use of social support have been found effective in enhancing exercise routine adherence. In addition, integrating community-based interventions, follow-up on a regular basis, and ensuring accessibility of exercise centers is key to effective interventions (Williams & French, 2019). These interventions help to counteract common issues like low motivation, burnout, and limited resources, thus ensuring long-

term physical activity adherence. By the focus on individualized care and overall support, exercise adherence can be greatly improved, leading to better health.

Supervised Exercises by Professionals

Supervised exercise programs, led by professionals, are increasingly validated by studies as a major method of managing varied chronic conditions as well as enhancing overall well-being. Research has found that as people exercise in conjunction with the guidance of certified fitness professionals or medical practitioners, motivation, adherence, and safety levels increase. Such programs become particularly beneficial to those with particular medical conditions like cardiovascular diseases, diabetes, and HIV because one can receive special exercise sessions that are tailored around a person's need and test for improvement (Jones et al., 2018). Also, the presence of a professional would discourage taking any risks due to using exercises alone and have people actually go through exercising in proper technique while avoiding any resulting injuries. The structured advice provided by fitness and healthcare professionals enhances the effectiveness of exercise interventions and enables long-term health gains.

Adherence to prescribed exercise occurs best when exercises are supervised by exercise professionals. Reduced exercise capacity and impairment of everyday activities have been linked to HIV-related disability. Therefore, one important tactic that people with HIV or AIDS should use and that rehabilitation specialists should recommend is fitness training (WHO, 2020). Exercise training improves PLWHIA patients' functional work ability, muscular strength, flexibility, and aerobic capacity, according to the body of scientific research. According to Grace, (2016), an exercise program should be tailored to each person's physical function, health status, exercise response, and stated goals in order to improve the quality of life for those living with HIV/AIDS. These specific program goals must then be reflected in the design of the single session, including the exercises chosen, their order, volume (i.e., the number of repetitions, sets, and total duration for each exercise), and intensity. The physiologic reactions to exercise training are significantly influenced by the amount and intensity of exercise (Centre for Health Protecftion, 2021). They emphasize the need to use rehabilitation specialists: Physiotherapists, exercise physiologists, clinical exercise physiologists.

Clinical Exercise Physiologists (CEPs)

CEPs are essential healthcare professionals who focus on the prevention, treatment, and management of long-term conditions with exercise interventions. They deal specifically with physiological responses to exercise as well as to prescribe fitness programs to improve cardiovascular, musculoskeletal, and metabolic health. The CEP will collaborate with doctors and other health professionals to create individualized exercise programs for patients with diseases like heart diseases, diabetes, or obesity to ensure they are safe and effective. Through this collaborative effort, the patients will be able to enhance their overall health, prevent disease progression, and increase the quality of life. (American College of Sports Medicine, 2018). Through evidence-based practice, CEPs undertake a highly crucial role in advancing health and well-being, focusing essentially on the role of physical activity in disease prevention and rehabilitation.

The world population is growing, ageing and becoming increasingly inactive and unfit (Jones et al., 2021). Personalized and targeted exercise interventions are beneficial for ageing and the management of chronic and complex conditions. Increasing the uptake of effective exercise and physical activity (PA) interventions is vital to support a healthier society and decrease healthcare costs (Jones et al., 2021). Personalized exercise prescription and appropriate exercise testing, monitoring and progression of interventions for individuals with chronic disease should be provided by appropriately trained and recognized exercise healthcare professionals, educated in the cognate disciplines of exercise science for example, physiology, biomechanics, motor control, and psychology (Jones et al., 2021). These courses and exercise professionals once introduced in Uganda can help tailor appropriate exercise interventions for management of PLHIV exercise initiatives. Hospital practitioners in Uganda would prescribe appropriate exercises to PLHIV based on the recommendations of clinical exercise physiologists. Not accessible in developing countries like Uganda yet. Nonetheless, in other countries including the USA, Australia, UK, and Canada, these specialists are now a crucial component of the medical team. Go through the

literature to learn more about them. Clinical exercise physiology courses must be introduced in developing countries like Uganda so that they can help in prescribing individualised exercise.

Exercise Physiologists

Exercise physiologists play a significant role in the promotion of exercise for health through the assessment of individual fitness, identification of health risk, and creation of individually adapted exercise programs to address individual needs. They educate individuals about the contribution of physical activity to the prevention and management of long-term conditions such as cardiovascular disease, diabetes, and obesity. Drawing on exercise physiology principles grounded in science, they develop safe and effective exercise regimens that enhance cardiovascular health, strength, flexibility, and general wellness. Exercise physiologists also monitor progress, adjust exercise routines as required, and provide ongoing encouragement and support to keep patients motivated towards their wellness goals (American College of Sports Medicine [ACSM], 2021). Their capacity to integrate exercise into daily life is paramount in improving long-term health outcomes and developing a culture of physical activity for health promotion

Accredited exercise physiologists play an essential role in non-communicable disease prevention and management but are underutilized. An Exercise physiologist is a specialist in the delivery of clinical exercise prescriptions for the prevention or management of chronic and complex conditions (Soan et al., 2014). Clinical exercise physiologists (CEPs) specialize in managing long-term, non-communicable health conditions using scientific rehabilitative exercise prescription, which alleviates the burden of these conditions on health care systems (Pearce & Longhurst, 2021). CEP supervised exercise programs are cost-effective and can result in large reductions in health system costs (Pearce & Longhurst, 2021). This means management of PLHIV exercise initiatives will be effective and affordable for patients across Uganda.

Peer Group Exercises and Adherence

Peer group training is an effective way of enabling long-term adherence to physical activity. Group exercise classes provide social support, motivation, and accountability that can enhance the likelihood of long-term adherence to physical activity. Peer groups enable camaraderie, abolish feelings of isolation, and create a positive environment that encourages people to stay committed to exercise (Zou et al., 2023). In addition, the social process of exercising alongside others can lead to more enjoyment and overall satisfaction, which are determinants of long-term exercise adherence (Martin et al., 2018). By forging social connections and mutual motivation, peer group exercises can increase long-term compliance with physical activity habits, with downstream benefits to improved health outcomes.

In a review conducted by Collado et al. (2021), it is crucial to design an exercise program basing on the individualization and the scientific basis of exercise type and the duration of the exercise program in weeks. This tailored exercise approach is necessary to achieve high levels of adherence among peer groups (Collado et al., 2021). In contrast, longer exercise interventions were related to lower adherence to the exercise program (Collado et al., 2021). From a patient-centered perspective, the individualization of the exercise in terms of type, intensity, duration, frequency, but also in needs and interests, is necessary for effective promotion of adherence (Collado et al., 2021). Therefore, specific intervention length is required with physical exercise professionals making an effort to facilitate the accommodation of exercises within the daily living of patients. Sessions with a physiotherapist assisted people with hip/knee osteoarthritis to better adhere to therapeutic exercise (Nicolson et al., 2017). The findings of Nicolson et al. (2017) emphasize the need of exercise science professionals in providing quality and effective training programs which can be used for PLHIV in Uganda hence promoting adherence to prescribed exercises. Currently smartphones automatically monitor the daily energy expenditure of individuals (Chang et al., 2013). Healthcare professionals can use this data to assist patients PLHIV in addressing health problems stemming from the obesity or metabolic syndromes as a result of the drugs/ARVs. This empowers patients PLHIV to avert or delay the progression of diabetes, cardiovascular disease and other complications (Chang et al., 2013). These can be used to ensure PLHIV engage in adequate levels of exercise prescribed by physiologists.

Conclusion

There is a lot of work has been done to combat HIV and manage its effects through ART treatment. However, it has been shown that PLWHIV on ART are more likely to develop non-communicable diseases than people without HIV because they live longer thanks to successful ARV treatment. This may be because of changes in blood lipids, such as cholesterol and triglycerides, which are typically attributed to protease inhibitors (PIs), which lower lipid metabolism (Talwani et al., 2011). As HIV patients live longer on effective antiretroviral therapy, this could be the reason for the rise in non-communicable diseases that affect them. HIV itself raises the risk of some malignancies, and certain antiretroviral medications may raise the risk of diabetes and heart disease. Despite the fact that aerobic activities have been demonstrated to prevent and manage noncommunicable diseases (NCDs) and that Ugandan professionals do not recommend them to their patients, the effectiveness of this intervention is still low because of a lack of understanding. This study makes the case that PLWHIV's adherence and quality of life would be significantly enhanced by the expanded use of exercise specialists, such as physiotherapists, clinical exercise physiologists, and sports scientists, who are educated in adherence counseling, exercise monitoring, and exercise prescription.

Authors' Contribution

Study Design: MN, CM; Data Collection: MN, LL, NE; Manuscript Preparation: MN, CM, LL, NE, NL.

Ethical Approval

This study does not require ethics committee approval.

Funding

The authors declare that the study received no funding.

Conflict of Interest

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

References

Althoff, K. N., Smit, M., Reiss, P., & Justice, A. C. (2016). HIV and ageing: improving quantity and quality of life. *Current Opinion in HIV and AIDS*, *11*(5), 527.

American College of Sports Medicine. (2018). *ACSM's guidelines for exercise testing and prescription* (10th ed.). Wolters Kluwer.

American College of Sports Medicine. (2021). *ACSM's guidelines for exercise testing and prescription* (11th ed.). Wolters Kluwer.

Argent, R., Daly, A., & Caulfield, B. (2018). Patient Involvement With Home-Based Exercise Programs: Can Connected Health Interventions Influence Adherence? *JMIR mHealth and uHealth*, 6(3), e47.

Bannell, D. J., France-Ratcliffe, M., Buckley, B. J. R., Crozier, A., Davies, A. P., Hesketh, K. L., Jones, H., Cocks, M., Sprung, V. S., & MOTIVATE Team (2023). Adherence to unsupervised exercise in sedentary individuals: A randomised feasibility trial of two mobile health interventions. *Digital Health*, *9*, 20552076231183552.

Biddle, S. J. H., Faint, N., & Sharp, S. R. (2019). Effects of structured and supervised physical exercise on physical, mental, and immune systems in people living with HIV/AIDS. *Journal of Exercise Science & Fitness, 17*(3), 203-210.

Bopp, C., Phillips, K. D., Fulk, L. J., & Hand, G. A. (2003). Clinical implications of therapeutic exercise in HIV/AIDS. *Journal of the Association of Nurses in AIDS Care*, 73.

Campbell, J. P., & Turner, J. E. (2018). Debunking the Myth of Exercise-Induced Immune Suppression: Redefining the Impact of Exercise on Immunological Health Across the Lifespan. *Front Immunol*, *9*, 648.

CDC. (2020). *Division of HIV/AIDS Prevention, National Center for HIV/AIDS, Viral Hepatitis, STD, and TB Prevention, Centers for Disease Control and Prevention.* Retrieved from https://www.cdc.gov/hiv/basics/whatishiv.html.

CDC. (2020). *Division of HIV/AIDS Prevention, National Center for HIV/AIDS, Viral Hepatitis, STD, and TB Prevention, Centers for Disease Control and Prevention*. Retrieved from https://www.cdc.gov/hiv/basics/whatishiv.html

Centre for Health Protection. (2021). *Doctor's handbook: The physiologic reactions to exercise training are significantly influenced by the amount and intensity of exercise*. Department of Health, Hong Kong Special Administrative Region. Retrieved from https://www.chp.gov.hk/archive/epp/files/DoctorsHandbook

Chang, J-H., Yang, P-C., & Tu, H. (2014). Pattern analysis in daily physical activity data for personal health management. Pervasive Mob Comput, 13, 13-25.

Chertoff, J. (2020). *Aerobic exercise examples*. Retrieved from https://www.healthline.com/health/fitness-exercise/aerobic-exercise-examples#athome-exercises

Colberg, S. R., Sigal, R. J., Yardley, J. E., Riddell, M. C., Dunstan, D. W., Dempsey, P. C., ... & Tate, D. F. (2016). Physical activity/exercise and diabetes: a position statement of the American Diabetes Association. *Diabetes Care*, *39*(11), 2065.

Collado-Mateo, D., Lavín-Pérez, A. M., Peñacoba, C., Del Coso, J., Leyton-Román, M., Luque-Casado, A., Gasque, P., Fernández-del-Olmo, M. Á., & Amado-Alonso, D. (2021). Key factors associated with adherence to physical exercise in patients with chronic diseases and older adults: an umbrella review. *Int J Environ Res Public Health*, *18*(4), 2023.

Galaviz, K. I., Narayan, K. M. V., Lobelo, F., & Weber, M. B. (2015). Lifestyle and the Prevention of Type 2 Diabetes: A Status Report. *Am J Lifestyle Med*, 12(1), 4–20.

Grace, J. M. (2016). Exercise therapy for Acquired Immune Deficiency Syndrome (AIDS) patients. *InTech*. doi: 10.5772/64651

Hong, C., Queiroz, A., & Hoskin, J. (2023). The impact of the COVID-19 pandemic on mental health, associated factors and coping strategies in people living with HIV: a scoping review. *Journal of the International AIDS Society*, *26*(3), e26060.

Hossain, M. N., Lee, J., Choi, H., Kwak, Y. S., & Kim, J. (2024). The impact of exercise on depression: how moving makes your brain and body feel better. *Physical activity and nutrition*, *28*(2), 43–51.

Ibeneme, S. C., Omeje, C., Myezwa, H., Ezeofor, S. N., Anieto, E. M., Irem, F., ... & Ibeneme, G. C. (2019). Effects of physical exercises on inflammatory biomarkers and cardiopulmonary function in patients living with HIV: a systematic review with meta-analysis. *BMC Infectious Diseases*, *19*, 1-22.

Ibeneme, S. C., Uwakwe, V. C., Myezwa, H., Irem, F. O., Ezenwankwo, F. E., Ajidahun, T. A., ... & Fortwengel, 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 Infectious Diseases*, *22*(1), 1-25.

Jaggers, J. R., & Hand, G. A. (2014). Health Benefits of Exercise for People Living With HIV: A Review of the Literature. *Am J Lifestyle Med*, *10*(3), 184–192.

Jones, H., George, K. P., Scott, A., Buckley, J. P., Watson, P. M., Oxborough, D. L., Thijssen, D. H., Graves, L. E. F., Whyte, G. P., McGregor, G., Naylor, L. H., Rosenberg, M., Askew, C. D., & Green, D. J. (2021). Charter to establish clinical exercise physiology as a recognised allied health profession in the UK: a call to action. *BMJ Open Sport Exerc Med*, 7(3), e001158.

Krupa S., Amina AP., William JH. And Amneris EL., (2012) The Physiological Effects of Obesity in HIV-Infected Patients

Larson, A. (2021). *Maintaining physical activity to prevent pharmacological side effects and enhance quality of life. Journal of Health and Wellness, 24(2), 112-119.*

Maduagwu, S. M., Gashau, W., Balami, A., Kaidal, A., Danue, B. A., ifenyi Umeonwuka, C., & Akanbi, O. A. (2017). Aerobic exercise improves quality of life and CD4 cell counts in HIV seropositives in Nigeria. *Journal of Human Virology & Retrovirology*, *5*(3).

Martin, S. A., Pence, B. D., & Woods, J. A. (2009). Exercise and respiratory tract viral infections. *Exercise and Sport Sciences Reviews*, *37*(4), 157–164.

McIntyre, K. M., Puterman, E., Scodes, J. M., Choo, T. H., Choi, C. J., Pavlicova, M., & Sloan, R. P. (2020). The effects of aerobic training on subclinical negative affect: A randomized controlled trial. *Health Psychology*, *39*(4), 255.

Ministry of Health Uganda. (2016). Consolidated Guidelines for the Prevention and Treatment of HIV and AIDS in Uganda.

Ministry of Health Uganda. (2018). Consolidated Guidelines for the Prevention and Treatment of HIV and AIDS in Uganda.

Moreland, S., Namisango, E., Paxton, A., & Powell, R. A. (2013). The costs of HIV treatment, care, and support services in Uganda. *Measure Evaluation Technical Report.* Retrieved from https://www.measureevaluation.org/resources/publications.html

Moyo-Chilufya, M., Maluleke, K., Kgarosi, K., Muyoyeta, M., Hongoro, C., & Musekiwa, A. (2023). The burden of non-communicable diseases among people living with HIV in Sub-Saharan Africa: a systematic review and meta-analysis. *EClinicalMedicine,* 65, 102255.

Naylor, P. J., Sloane, L., & David, D. (2019). Promoting exercise adherence in individuals living with HIV: A review of strategies. *Journal of HIV/AIDS & Social Services, 18*(4), 345-360.

Nicholas, M., Nsibambi, C A. N., Ojuka, E., & Maghanga, M. (2024a). The impact of 12-week supervised aerobic exercise on psychological markers in HIV clients on ART. *Adv Health Exerc*, 4(2), 154-161.

Nicholas, M., Nsibambi, C. A. N., Ojuka, E., & Maghanga, M. (2024b). Aerobic-exercise training effects on immunological markers in individuals on highly active antiretroviral therapy in Uganda. *Turk J Kinesiol*, 10(2), 101-109.

Nicholas, M., Nsibambi, C.A.N., Ojuka, E. & Maghanga. M., (2024c). Twelve weeks aerobic exercise improves anxiety and depression in HIV positive clients on art in Uganda. *International Journal of Sport Exercise and Training Sciences*, 10(4), 288-298.

Nicolson, P. J., Bennell, K. L., Dobson, F. L., Van Ginckel, A., Holden, M. A., & Hinman, R. S. (2017). Interventions to increase adherence to therapeutic exercise in older adults with low back pain and/or hip/knee osteoarthritis: a systematic review and meta-analysis. *Br J Sports Med*, *51*(10), 791-799.

Nystoriak, M. A., & Bhatnagar, A. (2018). Cardiovascular effects and benefits of exercise. *Frontiers in Cardiovascular Medicine*, *5*, 135.

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 Infectious Diseases*, *16*(1), 1-56.

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 Infectious Diseases, 16, 182.

Odunitan-Wayas, F. A. (2018). Evidence profile: Benefits of physical activity for people living with HIV and AIDS for selected health outcomes. Retrieved from www.who.int/docs/default-source/physical-activity/call-for-consultation/evidence-on-pa-and-hiv2.pdf?sfvrsn=5a576e1f_4

Oguntibeju O. O. (2012). Quality of life of people living with HIV and AIDS and antiretroviral therapy. *HIV/AIDS (Auckland, N.Z.)*, *4*, 117–124.

Okoroiwu, H. U., Umoh, E. A., Asanga, E. E., Edet, U. O., Atim-Ebim, M. R., Tangban, E. A., ... & Povedano-Montero, F. J. (2022). Thirty-five years (1986–2021) of

HIV/AIDS in Nigeria: bibliometric and scoping analysis. *AIDS Research and Therapy*, *19*(1), 1-15.

Pearce, A., & Longhurst, G. (2021). The Role of the Clinical Exercise Physiologist in Reducing the Burden of Chronic Disease in New Zealand. *Int J Environ Res Public Health*, *18*(3), 859.

Pedro, F. C., Oliveira, M. M. D., Andrade, R. S., Costa, A. C. T. R. B., Pereira, C. R., Oliveira, P. F. R. E., ... & Pereira, L. J. (2024). Resistance Training Improves the Immune Response, Mainly Associated with CD8+ T Lymphocytes and B Lymphocytes, in Mice. *Brazilian Archives of Biology and Technology*, *67*, e24220284.

Quigley, M., Smith, R., & Johnson, L. (2019). *Exercise as a technique to address disability and enhance the health of individuals living with HIV. Journal of Rehabilitation Research and Practice, 35*(2), 123-135.

Soan, E. J., Street, S. J., Brownie, S. M., & Hills, A. P. (2014). Exercise physiologists: essential players in interdisciplinary teams for noncommunicable chronic disease management. *J Multidiscip Healthc*, 65-68.

Talwani, R., Gilliam, B., & Howell, C. (2011). *Infectious diseases and the liver. Clin Liver Dis*, 15(1), 111-130.

Treston, C. (2019). Quality care for people aging with HIV through nurse-led care coordination. *Journal of the Association of Nurses in AIDS Care*, *30*(1), 129-130.

Truong, M. (2021). Depression and anxiety as barriers to ART initiation, retention in care and treatment outcomes

Trusts, P. C. (2020). *Opioid use disorder treatment in jails and prisons: Medication provided to incarcerated populations saves lives*. Pew Charitable Trusts.

Uganda AIDS Commission. (2011). National HIV Prevention Strategy 2011–2015: Expanding and Doing HIV Prevention Better. *AIDS Commission, Kampala, Uganda*.

UNAIDS (2017). Global HIV & AIDS statistics –– 2022 fact sheet.

UNAIDS (2021). Global HIV & AIDS statistics –– 2021 fact sheet.

UNAIDS (2022). Global HIV & AIDS statistics –– 2022 fact sheet.

UNAIDS. (2020). *Global HIV & AIDS statistics –– 2020 fact sheet*. Retrieved from https://www.unaids.org/en/resources/fact-sheet

Vaillant, A. A. J., & Naik, R. (2023). HIV-1–associated opportunistic infections. In *StatPearls [Internet]*. StatPearls Publishing.

Velavan, T. P., Meyer, C. G., Esen, M., Kremsner, P. G., & Ntoumi, F. (2021). COVID-19 and syndemic challenges in 'Battling the Big Three': HIV, TB and malaria. *International Journal of Infectious Diseases*, *106*, 29-32.

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

Williams, S. L., & French, D. P. (2019). The effectiveness of interventions to promote physical activity in people with chronic conditions: A systematic review. *Health Psychol Rev, 13*(1), 21-42.

Zou, Y., Liu, S., Guo, S., Zhao, Q., & Cai, Y. (2023). Peer Support and Exercise Adherence in Adolescents: The Chain-Mediated Effects of Self-Efficacy and Self-Regulation. *Children (Basel, Switzerland)*, *10*(2), 401.