

**Title:** Effect of aerobic exercise on functional capacity and health status of individuals living with HIV/AIDS in Kano, Nigeria: a randomized controlled pilot study

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## Abstract

**Background:** The Human Immune-deficiency Virus/Acquired Immunodeficiency Syndrome (HIV/AIDS) and its associated complications have continued to be a major challenge to the health systems despite the use of alternative therapies. People living with HIV/AIDS (PLWHA) are known to suffer from impairments in functional capacity and health status among several other comorbidities requiring intervention. This present study was undertaken to investigate the effect of aerobic exercise on functional capacity and quality of life (QoL) in PLWHA.

**Methods:** Thirty PLWHA (20 males & 10 females;  $35.3 \pm 7.98$  years) were recruited from two tertiary hospitals in Kano State, Nigeria to participate in this study. The participants were randomly assigned to either experimental group (EG) or control group (CG). All participants were allowed to continue taking their prescribed anti-retroviral therapies (ART) medications throughout the study period. The EG received aerobic exercise training for 6 weeks in addition to ART use. The study focused on two outcomes; functional capacity and health status. These outcomes were measured at baseline and after 6 weeks in both groups. Functional capacity was assessed using 6 minute walk distance (6MWD), while health status was determined using the short form (SF) 36 questionnaire, which assess QoL in both physical (PCS) and mental component summary (MCS) scores separately. Both paired and unpaired samples t-test statistics were used to determine within and between group differences. Alpha level was set at  $P < 0.05$ .

**Results:** The results show that only subjects in the EG group recorded significant increase in functional capacity (6MWD; from  $211.5 \pm 16.9$  to  $222.7 \pm 13.4$  meters) after the intervention ( $p < 0.05$ ). The scores of PCS and MCS of the EG participants were also significantly increased from  $41.3 \pm 5.88$  and  $47.5 \pm 8.83$  points to  $48.7 \pm 5.1$  and  $55.6 \pm 6.23$  points, respectively ( $p < 0.05$ ). Conversely, subjects in the CG did not show any significant increase in all outcome measures

after six weeks ( $p>0.05$ ). Furthermore, between group statistics showed that while baseline data were comparable in the two groups ( $p>0.05$ ), the scores of all the outcomes measures (6MWD, PCS and MCS) were significantly higher in the EG at post-intervention ( $p<0.05$ ).

**Conclusion:** Aerobic exercise is potentially beneficial in improving functional capacity and health status of PLWHA.

**Key words:** HIV/AIDS; Quality of Life; Functional Capacity; Clinical trial; Exercise training

## **Introduction**

Following its discovery in 1981, the Human Immune-deficiency Virus/Acquired Immunodeficiency Syndrome (HIV/AIDS) epidemic has evolved to become the greatest challenge in global health, with some 34 million persons living with HIV worldwide (De Cock, Jaffe & Curran, 2012). Africa is the most affected region, with over 70% (over 20 million) of people with HIV/AIDS (PLWHA), and the devastation of its impact is still on the increase (Dixon, McDonald & Roberts, 2002; Piot et al, 2001). In Nigeria, it is estimated that about 3.6 million people live with the disease, making it the country with the second highest number of PLWHA in the world (Reis *et al*, 2005). Generally, HIV/AIDS places significant burden on several variables at individual levels in form of deaths and family strain, and at community levels in form of over-burdened health systems and poor socioeconomic circumstances (Walker et al, 2004).

People living with HIV/AIDS have several complications some of which lead to a radical alteration of physiological and psychological well-being (Dudgeon, 2004). Consequently, a multi-pronged intervention has been recommended for PLWHA. For example, the use of highly active antiretroviral therapy (HAART) is reported to not only prolong the life of PLWHA, but also give them opportunity of a healthier and more productive live than was possible at the beginning of the HIV/AIDS pandemic (Dudgeon, 2004). The use of HAART has significantly reduced the mortality of HIV-infected persons. However, this treatment is associated with a host of adverse effects: fatigue, nausea, pain, anxiety and depression (Ciccolo, Jowers, and Bartholomew, 2004). Another important intervention available to PLWHA is the use of non-pharmacologic complementary and alternative therapies. These interventions have been widely

reported to improve several health parameters during the prevention and management of complications associated with HIV/AIDS (Aucamp, 2008; Furler, 2003).

Aerobic exercise training is one of such interventions reported to be effective in improving several outcomes for PLWHA (Roubenoff et al, 2011; Dudgeon, 2004). Aerobic exercise largely depends on the aerobic energy generating processes, which have been shown to be beneficial for both healthy and diseased populations (Ciccolo, Jowers, and Bartholomew, 2004; Dimeo, 2001). The general notion is that aerobic exercise training is not only safe, but also beneficial in terms of increasing lean muscle mass, cardiorespiratory fitness, and improving muscular strength metabolic profile, and quality of life (QoL) for PLWHA (Jaggers and Hand, 2014; Clayson *et al*, 2006). However, a recent systematic review of 10 RCTs revealed that performing constant or interval aerobic exercise, or a combination of constant aerobic exercise and progressive resistive exercise for at least 20 minutes, at least three times per week for 4 weeks may only potentially be beneficial for PLWHA (O'Brien et al, 2004).

Another aspect to the management of PLWHA is that long-term use of life-extending antiretroviral medications can negatively affect the health status and functional capacity. The health status of PLWHA is also significantly associated with severity of depression, deterioration of work function, inconvenience resulting from medication schedules and medical appointments, lack of social support, negative stressors, and adverse effects of HAART (Yen et al, 2004).

Functional capacity on the other hand is an important measure of health status that allows for effective diagnostic means and prognostication (Fleg et al, 2000; Guyatt *et al*, 2007).

Studies that reported beneficial effects of aerobic exercise training in PLWHA have stated important limitations such as small sample sizes, large drop-out rates, undetectable increases in viral load, poor research design and generalizability, heterogeneity of participants baseline

variables and conflicting reports (O'Brien, et al, 2004; Roubenoff et al, 2011; Dudgeon, 2004). It is also pertinent to note that many patients with HIV/AIDS continue to struggle with numerous social problems such as stigma, poverty, discrimination, poor living conditions, depression, substance abuse, and cultural beliefs which can affect their functional capacity and health status (Fatiregun, Mofolorunsho, and Osagbemi, 2009; Aranda-Naranjo, 2004). The few studies on the role of aerobic exercise in PLWHA in Nigeria have only focused on the knowledge and awareness regarding the effect of aerobic exercise on cardio-vascular and CD4 count parameters (Ezema et al, 2014; Maduagwu et al, 2014). This study investigated the effect of aerobic exercise on the functional capacity and health status of PLWHA.

## **Methods**

### ***Participants***

The sample of this pilot study was recruited from a population of available male and female patients with HIV/AIDS attending Aminu Kano Teaching Hospital (AKTH) and Murtala Mohammed Specialist Hospital (MMSH), both in Kano State, Nigeria. All available participants were contacted from the medical outpatient departments in these hospitals. The PLWHA were recruited only if they had a stable condition (on active anti-retroviral drugs) and after they gave a written consent. Those with severe co-morbidities such as respiratory diseases, musculoskeletal disorders, hypertension (with malignant course), recent cardiac events and those who were already undergoing exercise training programs were excluded.

### ***Procedure***

Ethical approval for this study was sought and obtained from the Research and Ethics Committees of Aminu Kano Teaching Hospital (AKTH) and Murtala Mohammed Specialist Hospital (MMSH), Kano State. While controlling for gender matching, consecutive individuals

who met our inclusion criteria were randomly allocated into two groups (experimental and control) using a secret balloting (concealed paper) system. Each participant was asked to pick a paper ballot from a box containing the remaining ballots to determine whether the participant will be allotted to the experimental or control groups. The experimental group received aerobic exercise training in addition to taking their regular medication, while the control group did not receive any additional intervention aside from their regular medication.

Aerobic exercise was performed on a bicycle ergometer. The participants in this group exercised at an intensity of 50-60% of maximum heart rate (MHR), which represents a moderate intensity aerobic exercise. The exercise protocol was adapted from an earlier study (Jaggers et al, 2015).

The MHR in beats/minute for each participant was estimated by subtracting their age (in years) from 220. Each participant in the experimental group exercised at a frequency of at least 3 times/week and for a duration of 6 weeks. Each exercise training session lasted for about 30 minutes to about 45 minutes. Those participants who became exhausted, breathless, had feelings of discomfort or felt that they could no longer continue were asked to discontinue training.

Demographic parameters (age gender, weight& height) were collected at the onset of the study for all participants. The main study outcomes (functional capacity and health status) were assessed at baseline and post intervention (after 6 weeks) for both groups. The functional capacity was assessed using the six-minute walk distance (6MWD). The 6MWD has been earlier described and widely utilized as a useful measure of functional capacity (Enright, 2003).

Participants were asked to walk on a 30-meter corridor for 6 minutes, while they were been encouraged using standard phrases like “keep on going like this” or “you are doing well” at intervals. The distance covered after six minutes was recorded as the functional capacity. The health status was assessed using the short form 36 (SF36) questionnaire. The SF36 is a self-

report instrument which is reliable, valid and of good psychometric properties (Ware and Kosinski, 2001). The SF 36, assesses health status in 8 domains, namely general health, physical functioning, role physical, body pain, mental health, role emotional, social functioning and vitality. The first four domains make up the Physical Component Summary (PCS), while the last four domains make up the Mental Component Summary (MCS) scores. The final PCS and MCS score (a scale of 0-100 each) were generated using the scoring formula described by Ware and Kosinski (2001) with the higher the scores indicating better health outcomes.

### ***Data analysis***

Demographic and other clinical characteristics of the participants were summarized using descriptive statistics including mean, standard deviation, frequencies and percentages.

Independent samples t-test was utilized to determine between group (experimental and control group) differences for variables including demographics (age, height weight BMI) and outcome measures (6MWD, PCS and MCS). Dependent (paired) t-test was used to analyze within group differences. Alpha level was set at  $P < 0.05$  (probability value). Statistical Package for the Social Sciences (SPSS) 22.0. IBM® was used for all analyses.

### **Results**

Thirty PLWHA participated in this study. The demographic and characteristics summary as shown in Table 1 revealed that the comparisons of age, height, weight and BMI of both groups. The demographic variables of age and height were comparable, however, the control group participants had a significantly higher weight and BMI ( $p > 0.05$ ). The baseline results of the outcome measures of interest, 6MWD (for functional capacity) and PCS and MCS (for health status) of both the experimental and control groups were comparable ( $p > 0.05$ ) as depicted in

Table 1. Post intervention values for the 6MWD, PCS and MCS was significantly higher in the experimental group ( $p < 0.05$ ).

**Table 1:** Between group comparison of all outcome variables

Variables	Experimental group M±SD	Control group M±SD	p-value
Age	36.8±8.86	33.9±7.26	0.322
Height	1.65±0.08	1.64±0.05	0.645
Weight	67.3±7.99	74.8±2.65	0.002*
BMI	24.8±3.49	27.9±0.81	0.002*
Pre -test 6MWD	211.53±16.9	207.20±20.1	0.528
Pre-test PCS	41.3±5.88	41.3±7.49	0.983
Pre-test MCS	47.5±8.83	46.9±7.91	0.851
Post -test 6MWD	222.7±13.35	209±16.82	0.02*
Post-test PCS	48.7±5.06	41.5±7.32	0.004*
Post-test MCS	55.6±6.23	47.6±8.72	0.007*

**Key:** M; mean, SD; standard deviation, n; number, %; percent, BMI; body mass index\*; significant at  $p=0.05$  alpha probability level, 6MWD; six minute walk distance (in meters) test, PCS; physical component summary, MCS; mental component summary.

The results of this study further shows in Table 2 that significant within group changes (increase) in the outcome measure only occurred in the experimental group ( $p < 0.05$ ). Participants in the control group did not show any significant changes for all the outcome measures at the post intervention ( $p > 0.05$ ).

**Table 2:** Results of within group differences for pre and post intervention (paired t-test)

Variables	Pre-intervention M±SD	Post-intervention M±SD	p-value
<i>Experimental group</i>			
6MWD	211.53±16.9	222.7±13.35	0.004*
PCS	41.3±5.89	48.7±5.06	0.001*
MCS	47.5±8.83	55.6±6.23	0.001*
<i>Control group</i>			
6MWD	207.2±20.12	209±16.82	0.494
PCS	41.3±7.49	41.5±7.32	0.435
MCS	46.9±7.91	47.6±8.72	0.484

**Key:** M = mean, SD = standard deviation, n = number, % = percent, BMI = body mass index \* = significant at  $p=0.05$ , 6MWD = six minute walk distance (in meters) test, PCS = physical component summary score, MCS = mental component summary score.

## Discussion

This study assessed the effect of aerobic exercise on the functional capacity and health status of PLWHA in Kano State Nigeria. The results of our study showed a preponderance of males over

female participants. Even though, this is not in agreement with the reflection of the general gender distribution among newly infected HIV/AIDS patients (Türmen, 2003). The higher number of male participant in our study is mainly due to the willingness of available PLWHA to partake in the study. The results for the health status outcome was reported separately for the physical and mental component scores. This was done in order to show the specific effects of the aerobic exercise intervention on the outcomes. PLWHA are known to exhibit poor quality of life (Fatiregun, Mofolorunsho, and Osagbemi, 2009; Clayson et al, 2006; Jagers and Hand, 2014). Therefore, combining both scores may limit the subtle differences of our intervention. Moreover, HIV/AIDS has different negative impact on several important outcomes and several bodily systems (Aranda-Naranjo, 2004; Piot et al, 2001). The use of 6MWD to assessed functional capacity because of its global acceptability and reliability in testing various categories of both healthy and diseased populations.

The main results of our study showed that significant improvements were recorded in both functional capacity and QOL for the participants in the experimental group who received aerobic exercise in addition to conventional treatment. This findings strengthens the position of previous studies that opine the aerobic exercise is beneficial for PLWHA (Jagers and Hand, 2014; O'Brien et al, 2004). Specifically, aerobic exercise in the studies of Ezema et al (2014) and that of Lox, McAuley and Tucker (1996) revealed significant improvements several parameters such as blood pressure, CD4 count, depression, anxiety and QOL of PLWHA.

Our findings in this studies can be supported by several earlier reports in literature. Past studies related to aerobic conditioning intervention including arm ergometry, leg ergometry and aquatic exercise showed improved endurance capacity (Latimer-Cheung et al, 2013; Peterjan et al, 1996; Kemi and Wisløff, 2010; Smmith 2010). Aerobic exercises are also known to significantly

improve functional capacity even among patients with high rates of fatigue through its role in reorganizing the capillaries at tissue level in response to the increasing oxygen consumption ( $VO_2$ ) (Oncu, Durmaz, and Karapolat, 2009). Moreover, aerobic exercise training programmes can break a circle of inactivity, impaired performance and increased fatigability that is prevalent in most patients with chronic diseases (Öztürk, et al, 2011).

The use of aerobic exercise for improving functional recovery and QOL in PLWHA as shown in our findings has significant clinical implications. More importantly, clinicians been provided with extra options when planning intervention strategies for these patients. In addition, we have corroborated our findings with those of earlier studies that have reported on patient-important outcome measures (Jaggers and Hand, 2014; Ezema et al (2014; O Brien et al, 2004). Our study serves as a potential background for widening the intervention strategies for PLWHA in centers with limited health resource. Therefore, health care providers may consider incorporating supervised aerobic exercise training into the treatment options for PLWHA.

Nonetheless, there is need for clinical studies with larger sample sizes that will match participants by age and gender to reduce any possible confounders that we may have missed in our study. Since PLWHA may have individual differences that can determine their response to exercise training compared to healthy counterparts. The weight and BMI between the groups were significantly different. This was as a result of the non-computerized randomization procedure adopted. However, since the baseline outcome measures of interest were comparable prior to the intervention, it is unlikely that the difference in BMI had any general impact on our results of this study. The findings of our study is also limited to PLWHA without significant HIV co-morbidities. Nevertheless, these are interesting areas for future considerations.

## **Conclusion**

This pilot study showed that aerobic exercise training is beneficial for PLWHA. However, it is not known whether aerobic exercise has a similar beneficial effect in other sub-groups of PLWHA. Therefore, future studies with adequate sample sizes, using established exercise training protocols, that takes into account various clinical sub-groups of PLWHA are still necessary.

**Conflict of interest:** None

## References

- Adurogbangba, M.I., Aderinokun, G.A., Odaibo, G.N., Olaleye, O.D. and Lawoyin, T.O., 2004. Oro-facial lesions and CD4 counts associated with HIV/AIDS in an adult population in Oyo State, Nigeria. *Oral Diseases*, 10(6), pp.319-326.
- Aranda-Naranjo, B., 2004. Quality of life in the HIV-positive patient: implications and consequences. *Journal of the Association of Nurses in AIDS Care*, 15(5), pp.20S-27S.
- Aucamp, C.M., 2008. *The use of complementary and alternative therapies among adult HIV positive patients in an outpatient setting* (Doctoral dissertation, Stellenbosch: University of Stellenbosch).
- Chin, J., 1990. Current and future dimensions of the HIV/AIDS pandemic in women and children. *The Lancet*, 336(8709), pp.221-224.
- Ciccolo, J.T., Jowers, E.M. and Bartholomew, J.B., 2004. The benefits of exercise training for quality of life in HIV/AIDS in the post-HAART era. *Sports Medicine*, 34(8), pp.487-499.
- Clayson, D.J., Wild, D.J., Quarterman, P., Duprat-Lomon, I., Kubin, M. and Coons, S.J., 2006. A comparative review of health-related quality-of-life measures for use in HIV/AIDS clinical trials. *Pharmacoeconomics*, 24(8), pp.751-765.
- De Cock, K.M., Jaffe, H.W. and Curran, J.W., 2012. The evolving epidemiology of HIV/AIDS. *AIDS*, 26(10), pp.1205-1213.
- Dimeo, F., Bauer, M., Varahram, I., Proest, G. and Halter, U., 2001. Benefits from aerobic exercise in patients with major depression: a pilot study. *British Journal of Sports Medicine*, 35(2), pp.114-117.
- Dixon, S., McDonald, S. and Roberts, J., 2002. The impact of HIV and AIDS on Africa's economic development. *BMJ*, 324(7331), pp.232-234B.
- Dudgeon, W.D., Phillips, K.D., Bopp, C.M. and Hand, G.A., 2004. Physiological and psychological effects of exercise interventions in HIV disease. *AIDS Patient Care and STDs*, 18(2), pp.81-98.
- Enright, P.L., 2003. The six-minute walk test. *Respiratory Care*, 48(8), pp.783-785.
- Ezema, C.I., Onwunali, A.A., Lamina, S., Ezugwu, U.A., Amaeze, A.A. and Nwankwo, M.J., 2014. Effect of aerobic exercise training on cardiovascular parameters and CD4 cell count of people living with human immunodeficiency virus/acquired immune deficiency syndrome: A randomized controlled trial. *Nigerian Journal of Clinical Practice*, 17(5), pp.543-548.
- Fatiregun, A.A., Mofolorunsho, K.C. and Osagbemi, K.G., 2009. Quality of life of people living with HIV/AIDS in Kogi State, Nigeria. *Benin Journal of Postgraduate Medicine*, 11(1).
- Fleg, J.L., Piña, I.L., Balady, G.J., Chaitman, B.R., Fletcher, B., Lavie, C., Limacher, M.C., Stein, R.A., Williams, M. and Bazzarre, T., 2000. Assessment of functional capacity in clinical and research applications an advisory from the Committee on Exercise, Rehabilitation, and Prevention, Council on Clinical Cardiology, American Heart Association. *Circulation*, 102(13), pp.1591-1597.

- Furler, M.D., Einarson, T.R., Walmsley, S., Millson, M. and Bendayan, R., 2003. Use of complementary and alternative medicine by HIV-infected outpatients in Ontario, Canada. *AIDS Patient Care and STDs*, 17(4), pp.155-168.
- Guyatt, G.H., Ferrans, C.E., Halyard, M.Y., Revicki, D.A., Symonds, T.L., Varricchio, C.G., Kotzeva, A., Valderas, J.M., Alonso, J.L. and Group, C.S.C.M., 2007, October. Exploration of the value of health-related quality-of-life information from clinical research and into clinical practice. In *Mayo Clinic Proceedings* (Vol. 82, No. 10, pp. 1229-1239). Elsevier.
- Hays, R.D., Cunningham, W.E., Sherbourne, C.D., Wilson, I.B., Wu, A.W., Cleary, P.D., McCaffrey, D.F., Fleishman, J.A., Crystal, S., Collins, R. and Eggen, F., 2000. Health-related quality of life in patients with human immunodeficiency virus infection in the United States: results from the HIV Cost and Services Utilization Study. *The American Journal of Medicine*, 108(9), pp.714-722.
- Jaggers, J.R., Hand, G.A., Dudgeon, W.D., Burgess, S., Phillips, K.D., Durstine, J.L. and Blair, S.N., 2015. Aerobic and resistance training improves mood state among adults living with HIV. *International Journal of Sports Medicine*, 36(02), pp.175-181.
- Jaggers, J.R. and Hand, G.A., 2014. Health Benefits of Exercise for People Living With HIV A Review of the Literature. *American Journal of Lifestyle Medicine*, p.1559827614538750.
- Kemi, O.J. and Wisløff, U., 2010. High-Intensity aerobic exercise training improves the heart in health and disease. *Journal of Cardiopulmonary Rehabilitation and Prevention*, 30(1), pp.2-11.
- Latimer-Cheung, A.E., Pilutti, L.A., Hicks, A.L., Ginis, K.A.M., Fenuta, A.M., MacKibbin, K.A. and Motl, R.W., 2013. Effects of exercise training on fitness, mobility, fatigue, and health-related quality of life among adults with multiple sclerosis: a systematic review to inform guideline development. *Archives of Physical Medicine and Rehabilitation*, 94(9), pp.1800-1828.
- Lox CL, McAuley E, Tucker RS. Aerobic and resistance exercise training effects on body composition, muscular strength, and cardiovascular fitness in an HIV-1 population. *International Journal of Behavioral Medicine*, 1996;3(1):55-69
- Maduagwu, S.M., Gashau, W., Abdulazeez, K., Oyeyemi, A.Y., Kaidal, A., Aremu, B.J., Akanbi, O.A., Jaiyeola, O.A. and Jajere, A.M., 2014. Knowledge of effect of exercise on HIV-infected persons among health care professionals in North Eastern Nigeria. *Journal of Exercise Science and Physiotherapy*, 10(1), p.31.
- Mbada, C.E., Onayemi, O., Ogunmoyole, Y., Johnson, O.E. and Akosile, C.O., 2013. Health-related quality of life and physical functioning in people living with HIV/AIDS: a case-control design. *Health and Quality of Life Outcomes*, 11(1), p.1.
- O'Brien, K., Nixon, S., Tynan, A.M. and Glazier, R.H., 2004. Effectiveness of aerobic exercise in adults living with HIV/AIDS: systematic review. *Medicine and science in sports and exercise*, 36, pp.1659-1666.
- Oncu, J., Durmaz, B. and Karapolat, H., 2009. Short-term effects of aerobic exercise on functional capacity, fatigue, and quality of life in patients with post-polio syndrome. *Clinical Rehabilitation*, 23(2), pp.155-163.

- Öztürk, A., Şimşek, T.T., Yümin, E.T., Sertel, M. and Yümin, M., 2011. The relationship between physical, functional capacity and quality of life (QoL) among elderly people with a chronic disease. *Archives of Gerontology and Geriatrics*, 53(3), pp.278-283.
- Peeters, M., Esu-Williams, E., Vergne, L., Montavon, C., Mulanga-Kabeya, C., Harry, T., Ibrinke, A., Lesage, D., Patrel, D. and Delaporte, E., 2000. Predominance of subtype A and G HIV type 1 in Nigeria, with geographical differences in their distribution. *AIDS research and human retroviruses*, 16(4), pp.315-325.
- Petajan, J.H., Gappmaier, E., White, A.T., Spencer, M.K., Mino, L. and Hicks, R.W., 1996. Impact of aerobic training on fitness and quality of life in multiple sclerosis. *Annals of neurology*, 39(4), pp.432-441.
- Piot, P., Bartos, M., Ghys, P.D., Walker, N. and Schwartländer, B., 2001. The global impact of HIV/AIDS. *Nature*, 410(6831), pp.968-973.
- Reis, C., Heisler, M., Amowitz, L.L., Moreland, R.S., Mafeni, J.O., Anyamele, C. and Iacopino, V., 2005. Discriminatory attitudes and practices by health workers toward patients with HIV/AIDS in Nigeria. *PLoS Med*, 2(8), p.e246.
- Roubenoff, R., Skolnik, P.R., Shevitz, A., Snyderman, L., Wang, A., Melanson, S. and Gorbach, S., 2000. Effect of a Single Bout of Acute Exercise on Plasma Human Immunodeficiency Virus RNA Levels. *Journal of Cardiopulmonary Rehabilitation and Prevention*, 20(1), p.65.
- Smith, P.J., Blumenthal, J.A., Hoffman, B.M., Cooper, H., Strauman, T.A., Welsh-Bohmer, K., Browndyke, J.N. and Sherwood, A., 2010. Aerobic exercise and neurocognitive performance: a meta-analytic review of randomized controlled trials. *Psychosomatic Medicine*, 72(3), p.239.
- Türmen, T., 2003. Gender and HIV/aids. *International Journal of Gynecology & Obstetrics*, 82(3), pp.411-418.
- Walker, N., Grassly, N.C., Garnett, G.P., Stanecki, K.A. and Ghys, P.D., 2004. Estimating the global burden of HIV/AIDS: what do we really know about the HIV pandemic?. *The Lancet*, 363(9427), pp.2180-2185.
- Ware, J.E. and Kosinski, M., 2001. Interpreting SF&-36 summary health measures: A response. *Quality of Life Research*, 10(5), pp.405-413.
- Yen, C.F., Tsai, J.J., Lu, P.L., Chen, Y.H., Chen, T.C., Chen, P.P. and Chen, T.P., 2004. Quality of life and its correlates in HIV/AIDS male outpatients receiving highly active antiretroviral therapy in Taiwan. *Psychiatry and Clinical Neurosciences*, 58(5), pp.501-506.