Original Article

Balance as an assessment of health-related quality of life in people living with HIV

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ABSTRACT

Background: Balance and cognitive decline are impairments in people living with HIV (PLWH). These impairments predispose to fall-related injuries, affecting health-related quality of life (HRQoL). This study assessed standing balance and cognition after a three-month fitness program and its relationship to HRQoL. Methods: Fifty-four PLWH participating in a community-based fitness program participated in this study. Standing balance with eyes open and eyes closed was measured with a pressure mat. Cognition was assessed using the HIV dementia scale (HDS), while the Functional Assessment of HIV Infection (FAHI) was used as a measure of HRQoL. Paired t-tests compared balance values while linear regression explored the association between balance and HDS scores with HRQoL. Results: Balance values with eyes open improved significantly (p=0.04). Linear regression showed a significant association between the three predictors and HRQoL (r = .50; p = .017). Conclusions: Standing balance and mental status play a significant role in HRQoL in PLWH. **Keywords:** Standing balance; HIV dementia; HRQoL.

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INTRODUCTION

New advances in the management of the Human Immunodeficiency Virus (HIV) infection have increased the survival and longevity of those individuals with this diagnosis (Nakagawa, May & Phillips, 2013). However, this increase in longevity have opened the doors to other chronic cardiometabolic (Althoff, Smit, Reiss & Justice, 2016; Shah et al., 2012) , neurological (Centner, Bateman & Heckmann, 2013; Sullivan et al., 2011) psychiatric (Bauer, Ceballos, Shanley & Wolfson, 2005), musculoskeletal (Centner et al., 2013; Sullivan et al., 2011; Weitzmann, Ofotokun, Titanji, Sharma & Yin, 2016) and functional (Richert et al., 2011, Sullivan et al., 2011) impairments affecting Health Related Quality of Life (HRQoL). The interaction between these comorbidities has a direct impact on balance and gait, affecting all aspects of mobility in these individuals (Richert et al., 2011). In addition, these comorbidities can also increase the risk for falls in people living with HIV (PLWH), which can lead to subsequent fractures and disability (Bauer et al., 2005; Richert et al., 2011; Weitzmann et al., 2016). It has been estimated that approximately 50% of PLWH suffer from balance and gait disturbances (Bauer et al., 2005; Richert et al., 2011). Furthermore, approximately 18% of PLWH with balance and gait impairments have suffered a fracture leading to a 30% increase in mortality due to the fracture itself (Weitzmann et al., 2016).

Multiple factors appear to impair balance in PLWH. These include peripheral neuropathies, muscle weakness, fatigue, and central nervous system (CNS) damage specifically at the cerebellum and basal ganglia (Bauer et al., 2005; Centner et al., 2013; Sullivan et al., 2011). A fact regarding balance impairments is that they occur and continuously progress independently from body composition, frailty, and CD4+ T-cell count changes, which may indicate more a CNS disturbance (Bauer et al., 2005). Other fall-related predictors associated with falls, altered balance, and gait disturbances are depression (Weitzmann et al., 2016) and HIV dementia (Centner et al., 2013; Weitzmann et al., 2016). Although balance disturbances in PLWH started to be recorded in the late 80's and early 90's, the literature is scarce regarding reports of balance outcomes with exercise interventions and how other possible CNS impairments affect balance. The purpose of this investigation was to evaluate changes in balance after participation in a community-based health and fitness program and explore the relationship between balance, HIV dementia and HRQoL.

MATERIALS AND METHODS

This study took place at "La Perla de Gran Precio", a faith-based community health and alternative medicine center providing services to PLWH funded by the Department of Health and Human Services (DHHS) through the Ryan White Program in San Juan, Puerto Rico. Institutional ethics approval was obtained prior to the study. Specific information on how the center operates can be found elsewhere (Ortiz et al., 2014). Briefly, this center provides physical therapy, fitness, and alternative medicine services to low income ($\leq$\$12,000/year) PLWH. Upon referral from the immunologist all participants were screened by a licensed physical therapist with over three years of experience working with this population. The purpose of balance and cognition assessment as part of the physical therapy services is to enhance early detection of CNS impairments in this population with the final goal of early referral to neurological or mental health services. The outcome measures of interest were balance with eyes open and eyes closed in 10-seconds as measured by the displacement of center of pressure (CoP) using a MatScan™ pressure mat (Tekscan Inc., Boston, MA), cognitive function as assessed by the HIV Dementia Scale (HDS), and HRQoL as assessed by the Functional Assessment of HIV Infection (FAHI). After initial evaluation, each participant received a personalized exercise prescription. All measures were then repeated three months later.

Participants

A total of 80 PLWH were originally recruited in this study. Descriptive information of participants included are depicted in Table 1. All referrals of PLWH to the center were included in the study. Exclusion criteria comprised of: 1) incomplete data of the three outcome measures in the medical record; 2) diagnosis of AIDS due to restrictions from physician; 3) medical diagnosis of psychiatric disorders; 4) wounds or amputations on any lower extremity; 5) diagnosed advanced visual impairment such as retinopathy; 6) joint replacement in any of the lower extremities; 7) diagnosed vestibular or inner ear damage; and 8) any low back or lower extremity injury within the last three months. From the 80 original participants, a total of 54 met the criteria to be included in the analysis. Fifty-four PLWH records (women: 28; men: 26) had baseline data for the outcomes of interest and only 23 had three-month follow-up data for an attrition of 57.40%. Attrition rates of this magnitude have been reported as typical in this population (Ortiz et al., 2014). Due to the nature of services and resources of the Center, follow-up of participants who stop assisting to the Center is minimal.

Measures

The outcome measures of this investigation were used with the purpose of early diagnosis of central nervous system (CNS) dysfunction. Postural stability is the complex result of controlling multiple sensory inputs to maintain balance and sustain body orientation with the environment (Palmieri, Ingersoll, Stone & Krause, 2002; Shumway-Cook & Woollacott, 2017). This process involves a hierarchical ordering of sensory stimuli, selecting the most appropriate sensory system from the visual, vestibular, or proprioceptive components (Palmieri et al., 2002; Shumway-Cook & Woollacott, 2017). If more than one system is impaired, there will be a substantial loss of sensory information that is required to maintain postural stability (Palmieri et al., 2002; Shumway-Cook & Woollacott, 2017). Postural stability is operationally assessed by the displacement of the center of pressure (CoP). The CoP is determined as the average location of the upward projection of the ground reaction forces and is continually changing by muscular forces attempting to maintain control of the center of gravity (Palmieri et al., 2002; Shumway-Cook & Woollacott, 2017). Thus, the CoP is an indicator of neuromuscular responses of the body's postural-control system (Krisner, Colby, Borstad & 2018; Palmieri et al., 2002).

In addition, sway plays an essential role in overall postural alignment and balance, and its analysis is critical for understanding how the postural-control system maintains an upright bipedal posture (Palmieri et al., 2002; Shumway-Cook & Woollacott, 2017). In this investigation, we used a MatScan™ high definition pressure mat (Tekscan Inc., Boston, MA) to detect the covered area of the CoP in squared centimeters (cm^2). The covered area is the combination of the CoP path length and range in the anterior-posterior and medio-lateral directions (Palmieri et al., 2002; Zhen, Liang, Wang, Sheng & Ma, 2016). The sensors in the MatScan™ detect the displacement by the feet as the body sways anteriorly, posteriorly, or laterally estimating the entire covered area of displacement (Giacomozzi, 2010). CoP measurement through the MatScan pressure mat have been found to be reliable in both eyes open (ICC=0.87) and eyes closed (ICC=0.91) conditions, in addition to correlate with force platforms for the same conditions (r=0.92) (Brenton-Rule et al., 2012; Goetschius, Feger, Hertel & Hart, 2017).

Cognitive function has been related to poor physical performance in PLWH (Althoff et al., 2016; Hawkins, Brown, Margolick & Erlandson, 2017). To assess cognitive function, we used the HDS (Power, Selnes, Grim & McArthur, 1995; Skinner, Adewale, DeBlock, Gill, & Power, 2009; Wojna et al., 2007). This scale is a brief reliable screening tool for HIV-associated neurocognitive disorder subdivided in four subtests (Power et al., 1995). The subtests are divided in time taken to write the alphabet, recall of four words by repetition immediately after and five minutes later, time taken to draw a three-dimensional cube, and antisaccadic eye movements (Power et al., 2009; Wojna et al., 2007). A score of 10 points have been determined at the cut-

off for mild dementia when compared to neuropsychological testing (Power et al., 2009; Skinner et al., 2009; Wojna et al., 2007).

To evaluate HRQoL the FAHI was used. This instrument has shown to be highly reliable (Cronbach's alpha:0.73-0.94) and sensitive to change (Peterman, Cella, Mo & McCain, 1997; Viala-Danten, Dubois, Gilet, Martin, Peeters & Cella, 2010). The FAHI total score comprises of subscores in different domains; physical well-being, emotional well-being, functional well-being, social well-being, and cognitive function (Peterman et al., 1997; Viala-Danten et al., 2010). The total score for the FAHI have been associated ($r = 0.21$-0.30; $p < .0003$) with functional performance in activities of daily living (ADLs), with those reporting greater stressful events with the FAHI having poorer physical function and consequently lower HRQoL (Peterman et al., 1997; Viala-Danten et al., 2010).

Procedures

The balance assessment component of the physical therapy evaluation comprised of each subject standing in a static bipedal posture on the MatScan™ pressure mat with eyes open and eyes closed with arms folded across their chest for ten seconds during each condition. The tasks were completed with the mat on the hard surface of the floor. Eyes open was used for evaluating all systems (i.e., visual, vestibular, somatosensory input) while eyes closed (i.e., eliminating visual input) evaluated vestibular and somatosensory input.

For the FAHI, participants sat in a comfortable position and the questionnaire was provided in their language of preference (i.e., Spanish or English). The physical therapist was available to answer any questions if the participant had any doubt with the questionnaire items. The HDS was performed in a standardized manner (Power et al., 1996; Wojna et al., 2007) by the physical therapist performing the evaluation in either Spanish or English based on each participant's preference.

Exercise intervention

The exercise intervention has been described in detail elsewhere and was performed according to guidelines from the American College of Sports Medicine (ACSM) (Ortiz et al., 2014). Briefly, the intervention included a warm-up of approximately 20-30 minutes at an intensity of 60%-70% of heart rate reserve. The warm-up comprised of aerobic exercise such as bicycle, elliptical trainer, or walking on a treadmill based on the participant's physical capability. After the warm-up, there were a variety of strengthening exercises using weight machines, free weights, or elastic bands. The strengthening component included eight to twelve upper and lower strengthening exercises performed in three sets of 12-15 repetitions at 60%-80% 1RM based on participant's comfort (Ortiz et al., 2014). Bench press, arm curls, lateral pull-downs, rowing, and triceps pulls were used for upper extremity strengthening while leg press, leg extension, hamstring curls, calf raises, hip abduction/adduction, and hip extension were used as lower body exercises. A series of balance exercises were performed by using unstable surfaces such as foam mats or therapeutic balls and platforms. Participants performed functional exercises such as tandem walking or body-weight exercises on top of the unstable surfaces.

Analysis

Descriptive statistics were calculated for demographic data. Paired t-tests were used to compare pre-and post (3-month) balance scores for both conditions, HDS scores, and FAHI scores. Multiple linear regressions were performed to assess the association between balance and HDS scores and the combination of balance and HIV dementia with HRQoL.

RESULTS

Descriptive statistics are depicted in Table 1. Balance values with the eyes open improved significantly (p = 0.04) from baseline (3.78 ± 1.4 cm^2) to three months (0.84 ± 0.14 cm^2) post exercise participation (Table 2). Although, balance with eyes closed improved over time (2.26 ± 0.56 cm^2 – 1.42 ± 0.37 cm^2), such improvement was not statistically significant (p = 0.15). There were no changes across time in HDS and FAHI scores. The multiple linear regression model showed a moderate statistically significant association between the three predictors (balance eyes open and close, and HIV dementia with HRQoL (r = .50; r^2 = .25; p = .017). The most highly correlated predictors to HRQoL were balance with eyes closed (r = .31, p = .03), followed by HIV dementia scores (r = -.40; p = .005). The multiple regression between balance with eyes opened and closed with HDS was not statistically significant (r = 0.30; r^2 = 0.09; p = 0.21).

Table 1. Demographic variables

Variable	Mean ± SD
Age (years)	55.24 ± 10.09
Weight (kg)	70.51 ± 8.11
Height (cm)	165.97 ± 8.63
Annual income ($)	8058.79 ± 7185.89
Fat mass (%)	29.07 ± 12.02
Lean mass (%)	70.98 ± 12.00
CD4 (cells/μL)	649.70 ± 588.26
Viral load (copies/mL)	1656.67 ± 2145.56

Table 2. Baseline and 3-month follow-up balance, HDS, and FAHI scores

Variable	Baseline Measures	3-month follow-up
Balance Eyes Open (cm^2)	3.78 ± 1.4	0.84 ± 0.14*
Balance Eyes Closed (cm^2)	2.26 ± 0.56	1.42 ± 0.37
HDS (points)	11.05 ± 3.96	11.69 ± 3.82
FAHI (points)	90.50 ± 12.21	83.36 ± 27.30

**p = 0.04*
HDS: HIV Dementia Scale
FAHI: Functional Assessment of Human Immunodeficiency Virus Infection

DISCUSSION

The main purpose of this investigation was to evaluate the changes in balance after a three-month exercise intervention and the role balance plays in HRQoL in PLWH. The main findings suggest that standing balance and mental status play a significant role in HRQoL in PLWH. Although the association between all three predictors (balance with eyes open, balance with eyes closed, and HIV dementia scores) was moderate, it seems there are other factors that play a role in determining HRQoL in PLWH given this model only explains 25 percent of the variability of HRQoL in this population. Our findings agree with previous investigations (Bauer et al., 2005; Richert et al., 2011; Sullivan et al., 2011) in which balance disturbances appear to be primarily related to CNS dysfunction in this population. The CoP displacement exhibited by PLWH in this investigation (EO: 3.78 cm^2; EC: 2.26 cm^2) were far greater than values previously reported in the 70-year older adult population (EO: 0.91 cm^2; EC: 0.88 cm^2) (Zhen et al., 2016) and 30-year old healthy adults in firm (EO: 0. 62cm^2; EC: 0.54cm^2) and unstable surfaces (EO: 1.05 cm^2; EC: 0.87 cm^2) (Ruhe, Fejer & Walker, 2011) Brain imaging techniques to detect structural or neurophysiological damage or impairments are not

feasible in the clinical screening process due to high costs and high degree of testing and diagnostic expertise needed. Sullivan and colleagues (Sullivan et al., 2011) documented that balance and gait impairments are associated with structural damage of CNS structures, specifically the pons and cerebellum. Our data agrees with the notion of a CNS dysfunction (Bauer et al., 2005; Sullivan et al., 2011) given that the improvements observed in the eyes-closed condition (0.84cm^2) were not statistically significant. Therefore, given the complex integration of the postural-control system in maintaining balance (Bauer et al., 2005), postural control assessment would be a cost-effective, non-invasive, and fast screening procedure that might give an indication of early CNS dysfunction for timely referral to specialized clinical services.

Balance is a pre-requisite to ambulation and if impaired, it can increase the risk for falling during activities of daily living (Richert et el., 2011). Approximately 55% of PLWH will suffer from impaired balance and altered gait, increasing their likelihood to fall-related fractures and all its sequelae (Richert et el., 2011). Fall-related fractures primarily at the hip have an approximate mortality rate of 30%, and they are becoming more common in PLWH due to the use of anti-retroviral medications and the chronic inflammatory response of the immune system (Weitzmann et al., 2016). As it appears, T-cell repopulation and immune reconstitution, which often happens with ART use, are mechanisms associated with bone loss that can ultimately lead to the increased risk of fracture in PLWH (Ofotokun et al., 2016). Although sarcopenia can directly affect balance and gait, balance impairments have been documented before sarcopenia becomes apparent (Hawkins et al., 2017). Therefore, assessment of balance and gait related performance is imperative to detect impairments early preventing further complications such as falls. The moderate statistically significant association between balance and HRQoL agree with reports (Erlandson et al., 2014; Hawkins et al., 2017) that indicate PLWH who exhibit greater postural control and physical function enjoy of a better HRQoL possibly due to increased participation in activities in the society.

There are several limitations needing to be addressed before any conclusions can be drawn. Given that PLWH who visit the Center are seeking services who are part of the standard of care, a randomized controlled intervention would not be ethical. Secondly, the participants in this study did not undergo a standardized exercise prescription as it was personalized based on their fitness level and preference for exercises. However, all exercise prescriptions were based on ACSM guidelines targeting an aerobic, strength, endurance, balance, and flexibility components (Ortiz et al., 2014; ACSM, 2018) Nonetheless, the results of this investigation provide evidence on the importance of balance assessment in PLWH and the role balance plays in the bigger spectrum of HRQoL.

CONCLUSION

This investigation showed that standing balance can improve within three months of initiating a fitness program in PLWH. In addition, improvements in balance are associated with a greater HRQoL in this population. The combination of assessment of standing balance and HIV-related cognitive decline could be used as early detection tools for further referral to specialized neurological or mental health care in PLWH.

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