



Latinxs with HIV: Depressive Cognitive Alterations as a Precursor to Cardio-Motor Deficits

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Abstract: HIV is a debilitating infection that often presents with health-related complications, further reducing quality of life. Of the most common comorbidities accompanying HIV is depression, which can induce cognitive alterations alongside those resulting from the virus. Latinxs are disproportionately susceptible to both afflictions and face innumerable challenges in the identification and diagnosis of depression. Consequently, HIV-infected Latinxs may experience additional cognitive symptomatology from the simultaneous prevalence of depression and HIV, potentially affecting their gait and cardiovascular profiles. This study aimed to determine the impact of depression on cardio-motor components in HIV-infected Latinxs. Records of 291 stable HIV+ participants were collected from La Perla de Gran Precio Community Center, analyzed for depression, and respectively allocated to the depression group (70) and the group without depression (221). Cardio-motor values were obtained by conducting the Ross treadmill test, a submaximal cardiovascular assessment. An ANOVA revealed similarities in cardiomotor profiles between groups, alluding to the absence of depression-induced modifications to gait and cardiovascular health. Community exercise and cardiopulmonary intervention programs are beneficial to the quality of life in this population during all stages of HIV. However, HIV-infected Latinxs with depression face acute cultural challenges, causing diagnoses and treatment oversights and deficiencies for those who are suffering. Public health efforts should aim to remove barriers facing this population to ultimately reduce the inflated prevalence of both afflictions. Future research should focus on the crucial differentiation of Latinx depressive symptoms from those identical in HIV prior to reinvestigating cardiomotor alterations.

Keywords: Latinxs with HIV, Cardio-motor modifications, Depression-induced cognitive alterations, Minority health inequities, Community center, HIV-exercise



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1. Introduction

Globally, there are approximately 38 million people living with the human immunodeficiency virus (HIV), with 1.7 million new reported cases every year [1-2]. Without proper treatment, HIV and its complications are deadly and have claimed the lives of over 33 million people, to date, however, only 81% of those with the virus are aware that they have been infected [2]. While the virus does not discriminate based on gender, sexual orientation, age, race, socioeconomic status, or ethnicity, there are groups where the disproportionality of HIV infections is profound; African American and Latinx populations are most vulnerable to contracting the virus, generating the occurrence of HIV micro-epidemics at local levels in areas with higher percentages of either of the two groups [3-4]. As such, over half of all new HIV diagnoses in the United States occur in the south, at 15.6 diagnoses per 100,000 persons, and in Puerto Rico, at 13.6 diagnoses per 100,000 persons [4-5].

While HIV incidence rates have declined for African Americans and other racial groups since 2014, the number of new infections for Latinxs has increased to 18.4 diagnoses per 100,000 persons [6], as this population now accounts for 27% of the annual 38,000 new HIV cases in the US and its dependent territories [7-9]. Latino males comprise the majority of these unequivocally higher rates of infection in the Latinx population, are four times more likely to contract HIV [10], and are twice as likely to die from the virus than their white counterparts, making this group exceptionally susceptible [8,11]. Although barriers for prevention and treatment have been outlined, limited progress has been made to disaggregate definitive reasons for the disproportionately higher rates of HIV and poorer clinical outcomes for Latinxs [6]. Should similar rates of infection persist, it is expected that 22% of male Latinxs on the LGBTQ+ spectrum will contract the virus [4], making it vital to identify and address explicit reasons for the inflated amount of HIV infections in the Latinx population, along with their respective virus-related complications, such as depression and motor perturbations.

HIV is characterized by the invasion and debilitation of the immune system, leading to the decline of CD4+ cells and causing a dramatic increase in susceptibility to other diseases and infections [12].

This directly affects the nervous system, eliciting respective disorders and atrophic changes in the brain and nervous system, ultimately leading to motor and cognitive neurological alterations (MCNAs) [13-15]. MCNAs and related disorders resulting from HIV infections interfere with daily life and negatively impact the health and well-being of patients and their caregivers, their quality of life, and the healthcare system as a whole. Antiretroviral therapy (ART) has made significant advancements in viral suppression, allowing for greater life expectancies and decreased mortality rates for HIV-infected individuals, and is therefore a crucial treatment for people living with HIV [15]. Although the number of HIV-infected individuals receiving ART has increased by over 400% since 2009, the lack of testing, treatment availability, and overall healthcare allow for only 67% of those aware of their disease to procure treatment [1-2]. Additionally, adherence to ART has also posed an issue and is lower among Latinx males, mainly as a result of young age, poverty, unmet ancillary needs, and depression [10].

While ART has indisputable benefits, it does not prevent the development of comorbidities and disruptions often seen in those infected with HIV, such as cardiovascular, motor, and cognitive alterations [16]; in ART-treated individuals, the progression of their cognitive system disruption as a result of HIV is slowed, but cannot be aggregately prevented [15]. As is the case with diminishing cognition, motor and gait changes are also intransigent and pervasive in those with HIV, comprising a wide range of manifestations including the reduction or cumulative loss of fine motor skills, balance, and locomotion, as well as the induction of unsteady and slow gait, hyperreflexia, and bradykinesia [17]. Therefore, interferences from HIV-induced MCNAs remain, negatively impacting quality of life and posing detrimental risks for normal cognitive function, balance, and gait stability, which consequently increases the risk of falls, injury, and early death in those who are infected [13, 18-20].

Declinations in the cognitive system are seen in HIV-infected individuals after the virus crosses the blood-brain barrier and causes chronic inflammation, during which the white matter, macrophages, and monocytes in the brain are affected and give rise to the clinically significant neurocognitive impairments seen in those living with the virus [21]. In over 50% of HIV patients, some form of cognitive impairment is present and can impact verbal skills, working memory, attention to information, speed of information processing, information retrieval, learning, personality

and behavioral changes, executive functioning, and motor skills [21]. The prominence of these MCNAs are further amplified by common factors observed in HIV-infected individuals, including neurotoxicity, comorbidities, drug resistance, and poor ART adherence [22]. Although there is no uniform level of severity or specific timeline for the onset of HIV-induced cognitive hindrances [23], it is certain that such impairments and alterations of the frontal lobe will manifest in those with the virus, as the likelihood of development of greater neurocognitive alterations is directly proportional to having a longer lifespan while living with HIV. Given that the cognitive system is involved in a plethora of bodily functions and systems necessary for daily life, impairment of this system has been identified as a major complication of HIV [24].

Cognitive disruptions as a result of mental health disorders are also found in people with HIV, of which the most prevalent comorbidity is depression, as it occurs in 41% of those diagnosed with the virus [25]. Depression is nearly three times as likely to develop in HIV-infected individuals than in the non-infected population and presents a plethora of negative outcomes, including a further reduction in life expectancy and decreased chances of achieving viral suppression [26-28]. In those who have depression but do not suffer from HIV, cognitive and functional impairments, such as memory disorders, slow thoughts and responses, and frequent vegetative states, are common [29]. Additionally, depression in the Latinx population poses further risks to neurocognitive disruptions, as the mental health disorder presents with functional and somatic manifestations that are not as easily recognized by practitioners or the standardized, Eurocentrically designed depression screening tools [28,30]. Thus, the impairments from depression coupled with the cognitive alterations that are inevitably present in those with HIV pose calamitous risks to health, wellbeing, safety, debilitation, and life expectancy in those who have both morbidities, simultaneously. While ART and treatment for depression can reduce the effects of the comorbidities, it cannot completely negate the impacts these cognitive impairments have on various body systems.

Furthermore, physical comorbidities are also unremitted by ART; while lifestyle factors contribute greatly to health issues, the HIV-induced immune dysfunctions, inflammation, and ART effects also aid in the generation of such comorbidities [31]. In fact, ARTs often exacerbate the prominence of comorbidities

in people receiving treatment for HIV due to prolonged life expectancies with infection-related susceptibilities [31]. It has been found that over 97% of Latinxs diagnosed with HIV have at least one comorbidity, the most common of which relates to the cardiovascular system, including heart disease, hypertension, hyperlipidemia, and impairments in cardiac mechanics, as well as diabetes and smoking, all of which can cause vascular cognitive impairments [16, 32]. As such, we aim to discern the impact of depression on the gait and cardiovascular profiles in the HIV-infected Latinx population; therefore, we ask, do depression-induced cognitive alterations affect cardio-motor components in Latinxs living with HIV?.

2. Methods

2.1. Participants and Data Collection

Retrospective data from participants' records at La Perla de Gran Precio (LPDG) spanning the years 2000-2020 were gathered for this study. The LPDG is a community center located in San Juan, Puerto Rico, which aims to promote the quality of life of people living with HIV. This research was authorized by the LPDG and complied with the privacy and confidentiality standards appointed by the institution.

All project participants visited the LPDG, signed an informed consent form, and were authorized to participate by a physician, a physiotherapist, and a certified personal trainer who conducted an exercise assessment according to the requirements of the institution.

In this report, data related to participants' age, CD4 values, gender, time since HIV diagnosis, and comorbidities, are among what were collected. Additionally, as previously reported by Orozco and Rosario [33] for the same population, we utilized a submaximal cardiovascular assessment, the Ross treadmill test, to gather cardio-motor data.

2.2. Cardiovascular and Motor Components

The Ross treadmill test (RTT) measures the cardiovascular (blood pressure and heart rate) and gait-motor (treadmill speed and inclination) values of each participant during the test. Vitals such as blood pressure and heart rate were collected prior to initiating the RTT, and the cardio-motor data detailed in this study reflect the values following the culmination of the RTT. The protocol for the RTT was as follows:

- 1) Commence a speed of 2.0 mph with 0 inclination

- 2) Adjustment of the treadmill angle every 3 minutes at a sustained speed of 3.4 mph
- 3) Set a maximum tilt of 15 degrees after the initial 13 minutes
- 4) The RTT was then halted by the fitness trainer when either the target time of the RTT (21 minutes) had elapsed, the maximal cardiac frequency was achieved, or if participants experienced pain due to muscle fatigue or cardiovascular exhaustion.

2.3. Data Analysis

The intention of the current study was to discern and evaluate the implications of depression on cardiovascular and motor (cardio-motor) profiles in people living with HIV. As such, the data were allocated into two cohorts: a group with both HIV and depression (DPG) and a group with HIV without depression (non-DPG). The two categories of data collected and analyzed in this study were cardiovascular and motor patterns. Data for the motor considerations included the speed and inclination of the treadmill, whereas the completion time and vital signs (heart rate and blood pressure) when the RTT ended comprised the data for the cardio segment.

An analysis of variance (ANOVA) was conducted using SPSS version 25 to compare the DPG and non-DPG groups. A p-value equal to or below 0.05 was considered statistically significant.

3. Results

3.1. Table 1: Demographic, Years of Diagnosis, and CD4 Data

The data collected from the LPDG for the purposes of this investigation consisted of 291 participant records that were then analyzed for depression in order to appropriately allocate participants into either the DPG or non-DPG groups. As depicted in Table 1, the DPG consisted of 70 participants aged 52.6 $\pm$ 8.7 years with a mean of 17.7 $\pm$ 8.0 years since their HIV diagnoses. In the non-DPG, there were 221 participants who were 53.4 $\pm$ 10.7 years of age and had been diagnosed with HIV for a mean of 19.3 $\pm$ 8.6 years, as also seen in Table 1. Although the figures above are analogous, there were differences in CD4 values as the DPG presented with lower cell counts (610.8 $\pm$ 362.9) than the non-DPG (640.8 $\pm$ 350.5); however, this inadequate variance was statistically insignificant ($p=0.54$). Contrarily, while the majority of both groups were male, the difference in the number of females in

the DPG (0.37 $\pm$ 0.49) in comparison to that of the non-DPG (0.23 $\pm$ 0.42) was great enough to be deemed statistically significant ($p=0.05$).

3.2. Table 2: Cardiovascular and Motor Components

Data for the cardiovascular and motor components were collected from each participant following the completion of the Ross treadmill test. Values for the cardiovascular component included heart rate, systolic blood pressure, diastolic blood pressure, and cardiovascular test time. For the motor component, the aggregate figures for the velocity and inclination of the treadmill in the RTT were analyzed. The comparison of values for both components between the DPG and non-DPG cohorts, as illustrated in Table 2, was not statistically significant as the cardio-motor factors were nearly homogenous across groups. However, though insignificant ($p=0.09$), it should be underscored that the cardiovascular test time was lower in the DPG than the non-DPG, at 9.5 $\pm$ 4.7 seconds and 10.6 $\pm$ 4.7 seconds, respectively.

4. Discussion

This investigation aimed to comprehend the influence of depression on the gait and cardiovascular profiles of the HIV-infected Latinx population, as we sought to discern whether depression-induced cognitive impairments could consequently alter cardio-motor components in Latinxs living with HIV. Our study demonstrates that the cardiovascular elements represented by the heart rate variables and motor factors exemplified by the treadmill's velocity and inclination were comparable among the people living with HIV and depression group (DPG) and those living with HIV without depression group (non-DPG).

The current study reveals similarities in the cardiovascular aspects of the Ross treadmill test (RTT) in the DPG and non-DPG, highlighting that depression may not be an element affecting such variables in this population. The inclination of the treadmill mimics walking on the ground, and the difficulty of effort increases as the inclination angle increases [34]. However, while the treadmill speed and inclination for the RTT were equivalent between the two groups, both parameters were lower than what is typically standard for the test and, therefore, presented with equal reductions. As such, it should be noted that even with stable ART regimens and adequate CD4 cell counts, the prevalence and incidence rates of cardiovascular

[35], gait [36], and balance [37] dysfunctions are excessive in those infected with HIV.

Table 1 Demographic data of all participants. Results of ANOVA performed comparing Non-DN and DN groups Significance level set at $p \leq 0.05$.

Characteristics	Non-DPG n=221	DPG n=70	P value
Age (years)	M= 53.4+/-10.7 years	M= 52.6 +/-8.7 years	P= 0.24
Gender	Male= 0 Female= 1 M= 0.23+/-0.42	Male= 0 Female= 1 M= 0.37+/-0.49	P= 0.05
Year of Dx (years)	M= 19.3+/-8.6	M= 17.7+/-8.0	P= 1.4
CD4 count	M= 640.8+/-350.5	M= 610.8+/-362.9	P= 0.54
Non-DPG: Participant group diagnosed with HIV without depression DPG: Participant group diagnosed with both HIV and depression			

Table 2 Cardiovascular and motor components at the end of the Ross Treadmill Test. Results of ANOVA performed comparing Non-PN and PN groups Significance level set at $p \leq 0.05$.

Cardiovascular Component at the End of the Ross Treadmill Test				
Characteristics	Non-DPG n=221	DPG n=70	F Value	P value
Heart Rate (bpm)	M= 138.2+/- 18.1	M= 137.4 +/- 19.4	0.10	P= 0.75
Systolic BP (mmHg)	M= 124.5 +/- 16.9	M= 123.5 +/- 16.6	0.16	P= 0.68
Diastolic BP (mmHg)	M= 74.5 +/- 10.5	M= 76.1 +/- 12.1	0.85	P= 0.36
Cardio Test Time (sec)	M= 10.6 +/- 4.7	M= 9.5 +/- 4.7	2.9	P= 0.09
Motor Component at the End of the Ross Treadmill Test				
Velocity (mph)	M= 3.32 +/- 0.25	M= 3.27+/- 0.34	1.6	P= 0.21
Inclination (degrees)	M= 5.7 +/-4.2	M= 4.9+/- 4.1	2.1	P= 0.15
Non-DPG: Participant group diagnosed with HIV without depression DPG: Participant group diagnosed with both HIV and depression				

Although we emphasize the benefits of participating in a community-based exercise program, we are also mindful of the prospect that the resemblances identified between the groups could be attributed to other elements that may potentially have affected the subjects' cardio-motor profiles; among which are common comorbidities often seen in PLHIV, such as peripheral neuropathy and chronic pain. We further recognize that additional components might be related to similarities in the cardio-motor profiles of both groups, a variety of which will be considered below.

One possible explanation for the similarities between both groups is that all participants in this study were enrolled in a community program that focused on improving the quality of life of PLHIV through exercise. Previous research analyses have pointed out the multitudinous advantages of cardiovascular training including, but not limited to, improvements in cardiovascular health, mood [38], participation in daily living activities [39], and quality of life [40] in people living with HIV (PLHIV). Evidence has also shown that engaging in community-based exercise programs, such as that of the LPDG in this study, is beneficial to all those involved [41] and can help enhance immune function, cardiovascular fitness [33], muscle strength, and positive modifications in reducing metabolic risk factors for HIV-infected individuals [42]. The findings of Tsutsumi *et al.*, [43] were similar to those of the current study in relation to the benefits seen on attitude, anxiety, and physical activity resulting from participating in an exercise program. Nevertheless, contrary to our observations of the subjects' outcomes from participating in the LPDG community exercise program, the aforementioned authors perceived no significant cognitive treatment effects on the cohorts in their investigated exercise program [43].

Another possible justification for our results involves the substantial challenges of diagnosing and addressing depression in PLHIV, which are extensively acute in the case of Latinxs who have been infected with the virus. The prevalence of major depression in PLHIV is three-fold higher than that of the general global population [28], with as many as 41% of those with the virus experiencing depression [25]. Simoni *et al.*, [28] hold that the occurrence of depression in PLHIV is uniquely detrimental, as the mental health affliction interferes with necessary actions required for optimally managing HIV, such as adherence to ART, beginning ART following the increase in HIV RNA levels

and decrease in CD4 cell counts, lack of initiating ART entirely, and impaired self-care behaviors. These interferences have the ability to cause a plethora of spiraling negative outcomes that can lead to decreased viral suppression and life expectancy [26-27]. Latinxs with HIV, however, have distinctive strains associated with depression; the rates of depression among the Latinx population are higher than their non-Hispanic counterparts, yet only 20% of these individuals who are depressed speak to their primary care physician about their struggles, and only 10% go on to receive treatment for their mental health disorder [44]. This can be attributed to certain aspects of Latinx culture that greatly influence the identification, manifestation, disclosure, and diagnosis of depression, including cultural stigma, barriers in health literacy and education, age, parallel somatic and cognitive symptomology to HIV, and ART usage.

The negative stigmas associated with depression, other mental health disorders, and treatment in Latinx culture are immense and often lead to nondisclosure of their depression to their provider, non-treatment or low adherence to treatment, and somatization of their symptoms [45-49]. The historical context leading to the deep-rooted cultural stigmatization of depression was highlighted in a study by Interian *et al.*, [47], who found that Latinxs who disclosed or were labeled by their depression were mistreated in their communities, as well as in the healthcare system. Aside from the trepidation of mistreatment and failures of the healthcare system, present-day stigmas involve concerns over friends', families', and providers' perception of their mental health condition, and the belief that a person's mental health disorder should remain private and be overcome on their own [46]. Coincidentally, Latinxs frequently report having great shame and embarrassment in disclosing their depression and, therefore, are reluctant to discuss their emotional state with strangers such as physicians [45-46, 48]. As such, Simoni *et al.*, [28] found that Latinx patients with HIV who suffer from depression tend to not be forthright about their psychological symptoms and will only discuss them when specifically prompted by the provider; however, even with direct questioning, the severity of such symptoms are not communicated and are thus aptly unrecognized and remain undiagnosed.

Limited education and lower socioeconomic status allude to the poor self-identification of depressive symptoms due to reduced access to proper information on depression, symptoms of the disorder,

and factual evidence on respective treatments [46]. The cultural stigmas regarding antidepressant use have also been found to be firmly established within this population, as Lopez *et al.*, [46] reported views on treatment of depression to be independent of socioeconomic and educational status. The concern of antidepressants being addictive, along with the fear of being labeled weak, crazy, or as someone taking illicit drugs are additional reasons for the lack of disclosure, the refusal of treatment for depression, or for having low adherence to treatment [46-47]. Therefore, the willingness of a Latinx with depression to obtain treatment for their depression is largely based not only on their own contextual attitude, but that of their provider and support network, as well [47]. Coupled with the stigma associated with having HIV and the higher rates of depression in HIV-infected Latinxs, the concealment or lack of disclosure of depression further promotes the cyclical stigma surrounding depression in the Latinx community, further inhibiting progress in the minority stress framework while increasing rates of morbidity, mortality, and somatization of depression symptoms [51].

The subgroup of Latinxs who are further disproportionately affected by depression are older adults; poor symptom identification, nondisclosure of depression as a result of cultural stigma, and low rates of treatment, utilization of mental health services, and depression care are far greater in the older Latinx population, despite being more persistently ill and impaired as a result of the condition in comparison to their non-Hispanic counterparts [52]. However, older Latinxs are at an increased risk of depression, as Gonzalez *et al.*, [53] reported that they are twice as likely to suffer from the condition as those who are White or Black and in the same age group. Furthermore, intra-ethnic subgrouping is necessary to distinguish those in the Latinx population who are at even higher risk, such as Puerto Ricans. Adults from Puerto Rico, who are over the age of 55, have a 19.3% lifetime prevalence of major depression, and 27.9% of Puerto Ricans over the age of 65 have high depressive symptomatology, both of which are colossally greater than other Latinx and non-Hispanic populations [54]. Another analysis by Rodriguez-Diaz *et al.*, [16] reported that 19.2% of Puerto Ricans with HIV aged 50 and above also have depression. These figures for Latinxs with depression, along with the surge of depression in HIV-infected individuals, align with our findings as the average age of our subjects was 53 years, and 24.3% were diagnosed with the mental health disorder.

However, Jimenez *et al.*, [54] noted that older Latinxs are more reluctant in seeking help for their depression than younger Latinxs and other ethnic groups due to enhanced negative attitudes and stigma attached to disclosing their depression, along with the lack of proper education on mental health, depression symptomatology, and apprehension of provider discrimination [45]. Therefore, the rates of depression in our older HIV-infected subjects in Puerto Rico might be higher in reality than what was reported as a result of the factors above, especially when considering the overall prevalence of depression in HIV-infected individuals [25], as well as the older Latinx population independent of HIV [54]. The main concerns practitioners have for older Latinxs who are depressed, both with and without HIV, are the somatization of symptoms, psychosocial and problem-solving modalities, quality of life, suicidality, and cognitive impairments, as these are often exacerbated in individuals from this population [45,52].

In those who have been diagnosed with major depression, cognitive deficits due to the mental health disorder often induce alterations in gait, balance, and other motor components, as well as the accompaniment of specific gait patterns unique to actively being in a depressive state [55-56]. The cognitive symptoms and impairments most frequently cited by patients resulting from depression independent of HIV are deficits in processing speed, response time, attention, and executive functioning, along with frequent vegetative states [29]. While the specificity of these modification patterns were not observed in our subjects, their apparent absence may be attributed to the cognitive symptomatology for depression being strikingly similar to the MCNAs that are inevitably present in those with HIV; among these found in PLHIV are the alterations to verbal skills, working memory, attention to information, speed of information processing, information retrieval, learning, personality and behavioral changes, executive functioning, and motor skills, as reported by Mitra and Sharman [21]. Recent findings have also underscored the role of depression as a principal cause of MCNAs in PLHIV [57]. As such, associations made between cognitive functioning disruptions from depression in HIV-infected individuals have been ineffectual thus far [58], as the identical signs and symptoms make it difficult to distinguish whether the alterations are depression-induced or stem from the virus, itself.

Similar complications are present in differentiating between whether somatic and chronic

pain symptoms are from depression or HIV in individuals with both afflictions. The somatization of depression symptoms can manifest in a plenitude of bodily functions and systems that can result in being painful, worrisome, unpleasant, or uncomfortable [59]. The somatic and functional manifestations of depression among those in the Latinx population are often a direct result of symptom repression and somatic referral [46] due to the aforementioned influential cultural, socioeconomic, educational, and health literacy factors commonly found in this population, making the disorder harder to identify and disclose. As a result, even if patients are aware that their somatic symptoms are a direct result of their depression, it is very common for Latinxs to only mention their somatic alterations to their provider while purposefully concealing their depression or emotional disruptions [50,59]. However, while some Latinx patients may be aware of the emotional changes from their disorder, Goodmann *et al.*, [50] reported that it is not uncommon for the endorsement of somatic symptoms to occur independent of core emotional alterations. The most common symptoms are dysfunctions in digestion, sleep, appetite, fatigue, and cardiac arrhythmias [59-60]. It should be noted that in their study, Robinson and Monsivias [60] found that more than half of the Latinx subjects with depression experienced all of the above-mentioned somatic symptoms of the mental health disorder. The symptoms of somatizing depression in the Latinx population align with, and are nearly identical to, a multitude of those commonly seen in HIV-infected individuals [61], including effects on the cardiovascular system [62]. Thus, the prevalence of somatized depression further exacerbates the challenges faced by patients and providers by differentiating these symptoms from those HIV, and are therefore often dismissed as symptoms from the virus, generating detrimental oversights by providers in depression diagnoses.

A key issue reinforcing the challenges of identifying depression in Latinxs with HIV lies in the Eurocentricity of screening tools most often utilized by providers to identify depression. The vast majority of screening instruments have been developed based on Eurocentric manifestations of depression, while under the assumption that the symptomatology of the affliction is uniform and independent of race, culture, religion, and ethnicity [28]. It is known, however, that this is not the case for Latinxs, as Simoni *et al.*, [28] have found that even minor factors in these screening tools, such as verbiage on how the individual has been

feeling, lack cultural equivalence relevant to this population; for example, it is common for Latinxs to describe depressive symptoms as feeling nervous, rather than the current-standard of testing measuring for feeling "blue" or "downhearted," as often described by non-Hispanics with depression [28,63]. Additionally, standard depression screening tools were not designed for sensitivity to symptoms that are less severe or Latinx-associated somaticized depressive symptoms, although these types of symptomatology are most commonly observed in HIV-infected individuals with the disorder [50,58,60]. However, providers have noted that the use of screening tools to include somatic symptoms can also hinder their ability to diagnose depression in this population, as it creates further difficulty in differentiating between symptoms of HIV [64], as previously explained. Inevitably, these gaps between providers, tools, and Latinx culture lead to the oversight, misdiagnoses, or misunderstanding of Latinx patients, which prevents PLHIV and depression from obtaining necessary treatment. When considering how influential aspects of Latinx culture are on the assessment of depression, it is vital to use culturally relevant and sensitive instruments, as well as ensuring that providers are culturally competent and knowledgeable about the barriers, stigmas, and manifestation of depression unique to their Latinx patients.

One final explanation for our findings may be that our subjects were, in fact, less depressed as a result of their proper usage and adherence to ART. Tao *et al.*, [25] reported a direct association between depression and the non-use of ART in PLHIV; those with both depression and HIV are 14% less likely to receive proper ART treatments in comparison to those who do not have depression. In the current study, all of our subjects were receiving ART treatments concordant with HIV health and treatment protocols, as required by the La Perla de Gran Precio community center, making this an additional possibility for why our subjects were reported to be less depressed than the overall HIV-infected Latinx population.

Constraints to this investigation may have contributed to the lack of association between cardiovascular profiles and depression-induced cognitive alterations in our Latinx subjects living with HIV, and are limitations worth highlighting for further investigation. First, the diagnoses of depression in our subjects were made by practitioners independent of the LPDG, therefore, we were unable to analyze the depressive symptomatology and severity of the

disorder in our subjects, nor assess the possibility of there being a greater prevalence of undiagnosed depression, as commonly seen in Latinx PLHIV. Second, all of the participants in our study were receiving ART and deemed able to participate at the LPDG fitness center, equating to this cohort being more independent and stable in their HIV diagnoses; this limitation averted us from studying a cohort, such as inpatients or those not receiving ART, who may have more prominent HIV-related complications, greater MCNAs, and, ultimately, more profound depression and its respective cognitive alterations. Third, the average age of our subjects was 53 years, thus, we were unable to delineate the impact of depression-related cognitive alterations on the cardio-motor components of younger Latinxs with HIV. Lastly, we do not currently have a tool substantial enough to measure the progression of cognitive alterations from depression in PLHIV and its impact on exercise, nor distinguish those symptoms and their impact from the MCNAs present in our participants as a result of their HIV infection status.

All of the above-mentioned extenuating circumstances surrounding the HIV-infected Latinx population which hinder their identification, disclosure, and diagnoses of depression have been detrimental, although there are possible solutions to alleviate these challenges. Public health education efforts should focus on making strides to remove the negative cultural stigmas associated with depression and HIV in Latinx communities, as well as to improve health education and literacy on the two afflictions in an effort to break the cycle of ART and antidepressant nonuse, which have caused their prevalence to be disproportionately higher than the global population. Culturally competent providers are also necessary in order to properly identify and diagnose depression in Latinx PLHIV in a timely manner to allow for appropriate treatment and the avoidance of additional debilitating effects the disorder afflicts on their patients. We also suggest additional screening tools to be developed specifically for those who are Latinx, as well as Latinxs with HIV, to identify depressive symptoms that are culturally relevant and sensitive to lower levels of symptomatology often found in PLHIV. Ideally, these tools should also be designed to aid culturally competent practitioners in differentiating somatized depressive symptoms from those established in PLHIV.

5. Conclusion

The current investigation aimed to unveil the impact of depression on the cardio-motor profiles of Latinxs living with HIV. While our study did not yield an association between depression-induced cognitive alterations and cardiovascular profiles in our Latinx subjects living with HIV, it did highlight the prominence of innumerable factors relating to the elements impacting Latinxs who are afflicted with both HIV and depression. Cultural aspects impacting the proper identification, diagnoses, treatment, and management of depression components, along with the explanation for the similarities found in the cardiovascular elements (heart rate variables) and motor characteristics (velocity and inclination of a treadmill) depict two sides of the same plaguing coin in the circumstances surrounding HIV-infected Latinxs. In conjunction with the limitations of this study, these factors may have potentially elicited obstructed results which do not reflect the dire reality of this vulnerable population. Nevertheless, our findings demonstrate the benefits of continually utilizing target heart rates in tailored cardiopulmonary intervention programs, the establishment of longitudinal interventions that capture the progression of gait and cardiorespiratory variables, and the accessibility of community-based institutions that aid in promoting the health and quality of life in Latinx PLHIV during all stages of this disease.

We recommend that future investigations focus on Latinx PLHIV with more severe forms of depression to comprehensively discern the impact of the disorder on gait and cardiovascular profiles in this population. Researchers should also consider using cohorts who are in less stable stages of their HIV, such as inpatients or those who do not use ART. Younger Latinxs with HIV may also provide substantial results, as they are less apt to adhere to guideline-concordant HIV treatment, while also having less cultural stigma associated with being depressed and disclosing their respective symptoms, as previously outlined. Additionally, given the prominence of the somatization of depression in the Latinx community, which is often independent of emotional symptoms, we also suggest that future studies consider this symptomatology and move to delineate these symptoms from those that result from HIV alone; in doing so, researchers will be able to isolate these symptoms to adequately comprehend the impact of depression on a plethora of HIV-related outcomes, such as disturbances in gait and cardiovascular components. However, since diagnosing depression in the Latinx population is acutely

challenging and often overlooked, we believe that the priority in researching depression in HIV-infected Latinxs should initially lay in creating culturally equivalent depression screening measures and stigma reduction, as well as the differentiation between Latinx-based somatic and cognitive depressive symptoms from HIV symptomatology, followed by the aforementioned future recommendations regarding their impact on cardio-motor components in Latinx PLHIV.

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