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Working Status and Seasonal Meteorological Conditions Predict Physical Activity Levels in People Living With HIV

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Working Status and Seasonal Meteorological Conditions Predict Physical Activity Levels in People Living With HIV

Abstract

Little is known about how demographic, employment and meteorological factors impact physical activity. We conducted an analysis to explore these associations from participants (*N* = 447) from six cities in the United States and matched their activity data with abstracted local meteorological data from National Oceanic and Atmospheric Administration (NOAA) weather reports. Participants were purposively recruited in 3-month blocks, from December 2015 to October 2017, to reflect physical activity engagement across the seasons. We calculated total physical activity (minutes/week) based on 7-day physical activity recall. Mild correlations were observed between meteorological factors and correlated with lower physical activity. Participants were least active in autumn (Median = 220 min/week) and most active in spring (Median = 375 min/week). In addition to level of education and total hours of work, maximum temperature, relative humidity, heating degree day, precipitation and sunset time together explained 17.6% of variance in total physical activity. Programs assisting in employment for PLHIV and those that promote indoor physical activity during more strenuous seasons are needed. Additional research to better understand the selection, preferences, and impact of indoor environments on physical activity is warranted.

Keywords: climate change, HIV, physical activity, weather, work

Introduction

The physical activity level of people living with HIV (PLHIV) falls short of global health guidelines (Webel et al., 2019). Physical activity is defined as both daily activities and the activity during working time, and leisure time (Sallis et al., 1985). Globally, 23% of adults did not meet the World Health Organization's guideline of 150 minutes of moderate to vigorous physical activity per week (World Health Organization, 2018). These numbers are significantly lower among PLHIV. A review of 24 studies (N = 3,780) showed that 49.3% of PLHIV failed to achieve the physical exercise guidelines and were less active than people living with other chronic diseases (Vancampfort, Mugisha, De Hert, et al., 2018). Barriers to engaging in physical activity in PLHIV have been studied and include older age, high HIV-related symptom burden, depressive symptoms, fear of HIV stigma, and limited access to indoor exercise facilities (Montoya et al., 2019).

Physical activity is a key health behavior that promotes overall health and quality of life in PLHIV (Martin et al., 2019). Declining CD4+ T cells, HIV medications, and lipodystrophy (Vancampfort, Mugisha, Richards, et al., 2018) contribute to chronic pain and fatigue, which can prevent physical activity among PLHIV. Higher levels of physical activity in PLHIV are associated with better quality of life and overall physical function (Medeiros et al., 2017). For PLHIV on antiretroviral therapy, low physical activity is the primary indicator for low overall functional capacity, and it is common for middle-aged PLHIV to experience moderate functional impairment (Erlandson et al., 2012). Maintaining optimal levels of physical activity is crucial to reducing risk factors, including impaired functional level, obesity, cardiovascular diseases, and depression (Kamitani et al., 2017).

Although physical activity does not have a significant effect on viral load, engaging in physical activity has widespread physiological benefits, including improved cardiorespiratory fitness and muscular strength, and reduced depressive symptoms and anxiety (Jaggers & Hand, 2016). Metabolic changes induced by physical activity play a key role in preventing cardiovascular diseases, obesity, depression, and cancers, including better hormone regulation and sensitivity, improved cardiovascular function, decreased oxygen free radicals, and C-reactive protein levels (Kruk, 2007; Turner et al., 2017).

Although interventions to promote physical activity are effective in research settings, many PLHIV fail to integrate these interventions into their daily routines. A 2017 literature review demonstrated that many of the exercise intervention studies in PLHIV had more than a 30% attrition rate (Nosrat et al., 2017), indicating that more research is required to explore motivational factors and implementation strategies. Little is known about the effects of weather on physical activity levels in PLHIV. Evidence suggests that weather, or meteorological factors, which include temperature, rain, humidity, and snowfall, influence adults' participation in physical activity (Tucker & Gilliland, 2007). A Canadian report found that people are less physically active in winter than other seasons (Merchant et al., 2007). A Norwegian study suggests that outdoor recreational facilities have a positive effect on older people's physical activity levels (Viken et al., 2016). Additionally, people with higher social economic status (SES), who have access to a gym or fitness center, are more likely to participate in more physical activities than those with lower SES and limited access to fitness centers (Gordon-Larsen et al., 2006).

The purpose of this correlational study was to examine the relationships between physical activity, demographic, and meteorological factors for PLHIV in community settings in the U.S.

Methods

Design and participants

We performed a correlational analysis to explore the relationship between demographic and meteorological factors and weekly physical activity levels of PLHIV. The primary data was collected in the study*, "An Ecological Understanding of Physical Activity Patterns of Adults Living with HIV Throughout the Lifespan" (Webel et al., 2019).* Inclusion criteria for the study were (a) age 18 years or older, and (b) confirmed HIV diagnosis (HIV + ELISA with confirmatory PCR or Western blot). Exclusion criteria were (a) medical contraindications for exercise determined by the American Heart Association criteria or inability to be physically active without an assistive device (i.e., wheelchair, walker, or cane), (b) unable to understand English or Spanish, or (c) expected to move out of the area or plans to become pregnant within 12 months. Participants ($N = 447$) from six metropolitan areas were included in the data analysis, including Cleveland, Ohio ($n = 115$); New York City, New York ($n = 100$); Corpus Christi, Texas ($n = 140$); San Francisco, California ($n = 57$); Norfolk, Virginia ($n = 24$); and New Brunswick, New Jersey ($n = 11$). Due to a change in regulations by the National Oceanographic and Atmospheric Administration (NOAA) in 2018 on research studies access to weather information, the latter three study sites had incomplete meteorological data, which were treated as missing data. Data were collected via participants filling out an 18-item online questionnaire; a trained research assistant was available to assist as needed.

Measurements

Demographic variables: These variables were self-reported and included sex at birth, gender, sexual orientation, race/ethnicity, age, marital status, education, monthly income, number of children living with the participant, employment over prior 7-days, and housing status. In addition, 36-item social capital index was also used to measure participants' connection with the social network and environment (Nokes et al., 2012; Onyx & Bullen, 2000).

Meteorological variables: Weather data, including daily temperatures, barometric pressure, precipitation, wind speed and direction, heating or cooling degree day (above or below 65 degree F), humidity, and visibility were obtained from the NOAA weather reports. The local airport at each site was used as the primary weather recording location.

Physical activity: The 7-day Physical Activity Recall Instrument (PAR) (Sallis et al., 1985) was used to measure subjective recall of time in minutes spent in work and nonwork-related, total physical activity (total-PA), including light, moderate, and vigorous intensities, performed 7 days prior to the interview (*Examples of moderate and vigorous physical activity*, 2015; *Measuring physical activity intensity*, 2015; Sallis et al., 1985). Light physical activity (light-PA) refers to activities that require above 1.0 MET (metabolic equivalent) – the energy expended at rest, approximately 1 kcal/kg/hr – but less than 3.0 METs – activities such as slow walking, and cooking. Some examples of moderate physical activity (moderate-PA [3.0 METs < PA < 6.0 METs]) are brisk walking and gardening. Vigorous physical activity (vigorous-PA) requires above 6.0 METs, and examples include swimming or basketball. The PAR scale demonstrated adequate internal consistency (Cronbach's $\alpha = .842$) in our study.

Statistical analysis

Data were cleaned before analyses. Analyses were performed using SPSS V.25.0.0 (SPSS, Chicago, USA) and AMOS 28. The variable of interest, total-PA, displayed a significant deviation from the standard normal distribution; thus, median, and interquartile ranges were calculated. We transformed the total-PA to 'transformed total-PA' by adding 100 to each participant, conducting log transformation and winsorizing the outliers to meet assumptions of linear regression. Then, we analyzed physical activity level differences among demographic groups with Kruskal-Wallis *H* test with original total-PA, and ANOVA with log-transformed total-PA (ln[total-PA+100]). Spearman's correlations and 95% confidence intervals of these correlations were calculated to examine the associations between all variables. With the log-transformed total-PA as outcome variable, Multiple Linear Regressions (MLR, $p < .05$, Enter mode) were performed to examine the overall variance in physical activity. Structural Equation Modeling (SEM) was performed in AMOS to map the regressions among study variables. Each missing data was analyzed manually, and effort was made to retrieve them at each study site. All other missing data were treated as missing completely at random (MCAR). Pairwise deletion was applied to address the MCAR data in Kruskal-Wallis *H* test, ANOVA and Spearman's rho. Listwise deletion was applied to address the MCAR data in analyses of MLR and SEM.

Ethical approval

The study protocol, informed consent documents, and study procedures were reviewed and approved by the Institutional Review Board at each study site. All participants gave informed consent before initiating any study procedures.

Results

Changes in median physical activity according to demographic factors

Only 34.9% of participants (N = 447) reached the WHO's guideline of 150 minutes of moderate to vigorous physical activity per week. Demographic characteristics and median (Mdn) minutes of total physical activity are summarized in Table 1. Statistically significant factors associated with higher weekly physical activity included identifying as male, white, gay or bisexual, above high school education, employed, above $1,000 monthly income, not on disability, and sexually active.

Demographic factors correlated with physical activity are summarized in Table 2. There were statistically significant, weak correlations between being employed and total-PA (r = .195; *95%* CI [.104, .283], p < .001) and vigorous-PA (r = .182; *95%* CI, [.091, .270], p < .001). Higher level of education also had a weak association with total-PA (r = .204; *95%* CI [.113, .291], p < .001). Other variables (Birthsex, age, marital status, and disability status) only showed relatively small association with physical activity level and were non-significant determinants in the final regression model to predict physical activity.

Changes in median physical activity according to meteorological factors

Overall, study's participants (Figure 1) were more active in spring and winter than summer and autumn. The differences in total-PA across the 4 seasons were only significant between autumn and spring, and between summer and spring. In spring, study's participants (Table 3) from San Francisco (*Mdn* = 540 min/week), and Corpus Christi (*Mdn* = 458 min/week) reported a significantly higher level of total-PA than those from New York City (*Mdn* = 225 min/week). In winter, participants living in San Francisco (*Mdn* = 630 min/week) also had significantly more physical activity than those living in New York City (*Mdn* = 218 min/week). Corpus Christi participants were significantly more active in spring than autumn (p < .008). Associations between physical activity and changes in environmental factors, including temperature, humidity, day length, sunrise and sunset times, and level of precipitation are summarized in Table 2.

Impact of demographic and meteorological factors on physical activity

Multiple regression (Table 4) demonstrated (n = 409) that maximum temperature, relative humidity, heating degree day (above 65F), sunset time, precipitation, education, and total working hours in the past week significantly predicted the variance in total-PA, F (7,402) = 12.23, p < .001. The overall model R^2 was 17.6% (Table 4). When there is higher maximum temperature, not a heating day, lower relative humidity level, earlier sunset time and less precipitation, participants reported higher level of physical activity. An SEM model (Figure 2) was used to graphically display the linear relationships between study variables. Each path with an arrow represents a regression relationship between the connected two variables. The SEM model had 12 significant study variables remained in the mode with two endogenous and 10 exogenous variables. In addition to the main MLR model (in purple), we also found younger age, higher monthly income and higher social capital score significantly predicted longer hours participants worked in the past week.

Discussion

Our findings demonstrate that employment status, education level, and meteorological factors (i.e. Daily maximum temperature, relative humidity, sunset time, precipitation) were significant predictors of the level of physical activity in PLHIV. Our results showed there was no significant difference in physical activity among age groups. Contrary to our findings, other investigators identified that adults 65 years and older showed a decline in physical activity levels with age (Brandon et al., 2009; Mizumoto et al., 2015; Sumukadas et al., 2009; Yasunaga et al., 2008). Notably, females or White participants in our study had significantly less physical activity per week than their counterparts. This finding could be related to the higher incidence of chronic non-AIDS related comorbidity in women than others (Palella et al., 2019), and women's primary role within the household, which might give them less hours to work outside. We found divergent data suggesting that determinants of physical activity in PLHIV such as race and gender were uniquely different from other populations, which may help us better understand how to advise patients as they seek to increase physical activity.

Working and not receiving disability benefits were associated with increased physical activity in our study. Only 20.8% of participants were employed in their week of study participation, and about half of the participants (47.2%) were on temporary or permanent disability. We did not collect data on the causes or duration of their disability. We found that employed participants had approximately twice the physical activity compared to those who were unemployed. The finding of employment as a significant predictor for physical activity corroborates with another physical activity study of PLHIV, which found that employment explained 2.5% of variance in that study (Mabweazara et al., 2019). In the general population, a Dutch study documented that physical activity at work comprised approximately 30% of total physical activity in the middle age group (age 50-64), but was no longer a significant predictor after they retired at the age of 65 (Cepeda et al., 2018). In addition, others reported that more leisure time physical activity was positively associated with higher work ability level and less use of sick leaves (Päivärinne et al., 2019) or disability pensions (Fimland et al., 2015). Our results further revealed a positive reciprocal relationship between physical activity and work. It suggests that staying physically active improves an individual's work ability, and in return, the more work ability or hours of working is also associated with a higher level of physical activity. Therefore, strategies that maintain a working status for PLHIV should be addressed with unemployed individuals in this population to prevent developing a disability (Oliveira et al., 2018; Webel et al., 2018). Policies on employment and social activities should be encouraged for PLHIV. The United States Department of Labor and nonprofit organizations supports the notion that PLHIV should be employed with training and counseling to meet their occupational and health needs (U.S. Department of Labor, n.d.). Further studies should evaluate the barriers for PLHIV to access these public and nonprofit supports.

Meteorological factors were significantly related to PLHIV's physical activity levels. The higher the average or maximum temperature was, the less physical activity participants engaged in, though climate temperature change was not associated with changes in light physical activity. A study with healthy older residents in northern Japan (N = 201) showed that frequent outdoor activities were positively correlated with active participation in physical activity (Mizumoto et al., 2015). The influence of outdoor environment cannot be underestimated in promoting physical activity; a Canadian study (N = 20,197) found that people were 86% more likely to participate in leisure-time physical activity in summer than in winter (Merchant et al., 2007). However, we found that even after controlling for the average daily temperature, PLHIV in North America were less active in summer and autumn compared to winter and spring. This physical activity pattern in PLHIV contrasts with findings from three other studies in Japan, United Kingdom (U.K.), and the Netherlands. Day length, maximum temperature, and duration of sunshine explained about 73% of variance in physical activity, in both a 7-year study (N = 39) on healthy people from the age of 65 to 80 in Japan, and in a randomized control trial (N = 127) on people age 65 years or older in the U.K. (Kimura et al., 2015; Sumukadas et al., 2009). While these countries experience similar variation in seasons at the U.S., participants engaged in less physical activity during winter and more in summer and autumn (Kimura et al., 2015; Sumukadas et al., 2009). A population-based study (N = 1,116) from the Netherlands found similar seasonal pattern of physical activity for people between 50 and 75 years old, who were more active in summer than in winter (Cepeda et al., 2018). However, in China, Wang and colleagues (2017) did not find a correlation between temperature and physical activity in a younger age group (N = 40, *Mean Age* = 30, *SD* = 10), mainly due to the participants' full-time working status[36]. Furthermore, it is worthwhile mentioning that day length and sunshine duration were predictors of physical activity for studies both in the U.K. (Sumukadas et al., 2009) and Japan (Kimura et al., 2015). Though our study revealed a postive effect of earlier sunset time on physical activity level, the magnitude of the effect was small. Future longitudinal studies on the impact of meteorological factors should collect within-subject variations in different weather conditions and seasons, and sunshine duration should be included as a meteorological factor in analysis.

We found a weak, negative impact of precipitation on total physical activity in our study population. A study in northern Japan showed a decrease of 3.6% in subjects' pedometers with every 10 cm of snowfall (Mizumoto et al., 2015). In addition, as humidity increased, participants had higher levels of light physical activity. This is in contrast to the Netherlands, Cepeda and colleagues (2018) found the opposite to be true; Netherland has an average of 85% humidity level throughout the year, while, only 11% of our data showed above 80% humidity level.

With widespread changes in climate, the linear relationship between daily maximum temperature and total physical activity level is notable. Actions to slow down climate change (United Nations Sustainable Development Goal 13: Climate Action) can help mitigate social, environmental, and health-related consequences in affected communities, or excess mortality associated with heat waves (Guo et al., 2018). Individuals with chronic diseases and low socioeconomic support, such as many of the PLHIV in our study, may be less adaptive to temperature extremes and more vulnerable to climate change-related health consequences (Patel et al., 2019). Additional work is needed to better understand how to mitigate these consequences.

Limitations

There were several limitations to this study. First, our study was limited by the self-reported nature of the physical activity assessment. Second, there were no repeated measures on the same participants among different environmental conditions, and minimal information on medical and physical conditions of the participants. Third, three sites did not have complete meteorological information due to a regulation change in NOAA on access to weather reports.

Conclusion

This was the first study to evaluate demographic and detailed meteorological variables related to physical activity in PLHIV living in the United States. Our data demonstrated that 65.1% (n = 291) of participants in our sample did not meet the WHO's physical activity guidelines; much higher than what has been reported (49.3% in PLHIV and 23% in the general population) previously in the literature (Medeiros et al., 2017; Vancampfort, Mugisha, De Hert, et al., 2018; World Health Organization, 2018, Feburary 23). Our results showed that employment status was the primary determinant for physical activity in PLHIV in our study, and weather changes, including maximum temperature, humidity, sunset time, and daily precipitation, were secondary. Therefore, interventions to increase physical activity including those that help PLHIV gain employment, should continue to be developed. Further work on increasing awareness of work's impact on physical activity is needed; if not working, alternative strategies to increase physical activity should be integrated into daily routine such as using smart phone applications or wearable activity trackers to become more aware of their physical activity. In addition, longitudinal investigations will be necessary to identify the variation in physical activity in different seasons in the future. It is critical for communities to establish mitigation strategies to minimize the impact of climate changes on individuals' well-being. Because summer, with its higher outdoor temperatures, was associated with lower physical activity levels for PLHIV in our study, efforts should also focus more on promoting indoor exercise programs that can provide comfortable, stable temperatures and safety to minimize weather as a barrier to physical activity.

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