The effect of a 6 months African dance physical activity intervention on perceived physical fatigability: The Rhythm Experience and Africana Culture Trial (REACT)

by

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Abstract

Background/Objective: Sedentary lifestyles are associated with higher fatigue. Higher levels of fatigue observed with advanced aging contributes to lower levels of physical activities among older adults. African Americans have among the highest prevalence of physical inactivity compared to other races. They are disproportionally affected by health disturbances. Participating in regular physical activity plays an important role in reducing health disparities associated with disabling effects of aging. This study examines the effects of a 6-month African dance intervention on changes in perceived physical fatigability.

Methods: Twenty participants in the study were randomized into the African Dance group while the other twenty were in the control group. Physical fitness was measured using peak VO_2 and perceived physical fatigability with the Pittsburgh Fatigability Scale (PFS). Fatigue was measured using traditional fatigue questions from validated questionnaires. T-tests and Chi-squared tests were used to assess differences between the groups. Pearson correlation was used to assess the relationship between continuous variables.

Results: The mean age of the dance group was 66.1±4.36 and 67.3±4.98 for culture. Both groups showed low levels of fitness with a mean peak VO_2 of 16.6±5.17 for dance and 16.0±4.43 for culture. The mean physical fatigability level was slightly higher in the dance group (16.1±10.3) compared to culture (13.0±8.63) but the differences were not statistically significant, ($p=0.34$). The prevalence of greater perceived physical fatigability in this population was 50 percent with females reporting higher levels of perceived physical fatigability. PFS was correlated with measures of physical function and fitness. PFS physical scores increased post intervention in both groups, with and without adjusting for baseline peak VO2, sex and age, p=0.57.

Conclusions: The preliminary results from this pilot study do not provide a strong evidence of the effectiveness of the intervention in modifying perceived physical fatigability. Increased sample size from the full REACT cohort will be important to evaluate whether a dance intervention reduces perceived physical fatigability in older adults, as we know it is an important mediator in the relationship between physical activity and function. By identifying an enjoyable, culturally relevant intervention for older underserved adults, we can intervene along the disablement pathway.

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Preface

Life can be very difficult to navigate especially when you do not have any support. You can be very passionate and good about what you do but circumstances can prevent you from achieving your dreams if others do not step in to support your cause. I was very fortunate to have had tremendous support from a very young age. Being born in a remote village in South Africa can be a disadvantage at times due to limited resources and opportunities but I am thankful to my former high school biology teacher Ramaphoko JP who groomed me and invested in me. Thank you for helping me believe in myself and providing resources in times of need even beyond high school. My husband, Nathan Williams has been my rock. He helped me overcome daily mental and general struggles and helped create stability needed to excel academically and in life. His unconditional love, care, support and investment in me is unmatched. Dr. Glynn, has been more than a mentor and advisor. I am forever grateful for your continued guidance, care, love and support. I would also like to thank my essay committee, Dr. Kang and Dr. Erickson. Their expertise and support were amazing. I am grateful to Dr. Erickson, for giving me the opportunity to explore and apply my passion to work in cognition, aging and physical activity. Dr. Kariuki, provided a wonderful internship and learning experience with the Kenya Brain and Heart Health Study. Thanks are due to Susanna Qiao, Theresa Gmelin and Dr. Stillman-Coyne for their general input, expertise and advise with statistics. I am indebted to Dr. Lovell for introducing me to the world of epidemiology of aging and cognition. Many thanks are due to Eileen Lovell for being my Pittsburgh mother and always being there for me and my family! My love for public health came from very unfortunate circumstances after the loss of my father, mother and sister (Nduma, Mthavini and Tsakani Manganye). Their life lessons and advice continue to keep me motivated and drive me to want to achieve more in order to be part of the solution in the public health world. I would like to express my appreciation of my younger brother, Ntsako Manganye for his unconditional love, care, support and presence in my life. You are part of the reason I am here. You have always been there for me and for that, I am forever grateful! I would also like to thank my brothers Phillemon, Alarn and Nzama Manganye and Desmond Tshifhiwa Mabatha, my undergraduate professors from Nelson Mandela University, Dr. Maryna Baard and Mrs. Pippa Nell, and my in-laws Brenda, Kurt, Jean and Ebby Williams for their support early on in my

academic career. Lastly, I would like to thank God for helping me achieve dreams I never thought possible.

1. Introduction

1.1. Aging and Disability in Older Adults

The older adult population currently comprises a small percentage of the world population, but this is changing more rapidly than in the past. The World Health Organization (WHO) predicted that the aging population, those who are 60 and over, will make up 22% of the world's population by 2050. In 2050, 80% of the world's older adult population will be located in low - middle income countries where health care accessibility is very limited (Anon n.d.) . As the aging population increases, the public health world must brace itself and prepare to deal with chronic related issues that affect this population. According to the World Health Organization, around 1 billion individuals currently live with at least one disabling condition globally. The prevalence of disabilities is much higher among those who are 60 years and older. This increase in disability is due to various factors including the accumulation of health risks across a lifespan of disease, injury, chronic disease etc (Anon n.d.).

Center for Disease Control and Prevention (CDC) defines disability as any condition that causes impairment in a person's body or mind that restricts them from interacting with the world around them and performing certain activities (Anon n.d.) . Physical disability is a major adverse health outcome that is usually progressive and can result from several factors including underlying chronic disease, acute events (i.e stroke, car accident) and physiological changes associated with aging. It is currently estimated that 84% of Americans who are 65 years and over, who are dependent in activities of daily living (ADLs) or instrumental activities of daily living (IADLs) live in the community. The National Center for Health Statistics also estimates that 64% of those who are 85 years and older and suffer from similar disabilities live outside of nursing homes (Fried and Guralnik 1997). This means that most of the individuals will receive care in a home setting, and might be taken care of by a formal or informal care worker. Disability is associated with dependency and high health care costs (Fried and Guralnik 1997). The prevalence of disability increases with age and is much higher among older women aged 65 and older when compared to men. Women live longer than men and tend to experience more disability in their lifetime than men (Fried and Guralnik 1997).

Established Populations for Epidemiological Studies of the Elderly (EPESE) reported that the likelihood of losing mobility is doubled with each 10-year increase in age after 65 years (Fried and Guralnik 1997). The incidence of disability increases as people age and functional status declines. Fried et al also reported that individuals with an income of less than $10 000 per year or less than 8 years of education are 50 percent more likely to become disabled in ADLs or IALDs when compared to those with higher level of education and income. Coming from low socioeconomic status (SES) could predispose one to being disabled sooner (Fried & Guralnik, 1997). SES is also considered an important factor that explains high rates of disability among African American older adults. The relationship of linking disability to socioeconomic static status complicated due to possible confounding factors. For instance, the environment where a person lives can play a role in future health outcomes. Living in a neighborhood with high crime rate, lack of sidewalks, limited access to health care and inaccessible public transportation could contribute to reduced physical function leading to disability. Poor quality neighborhood environments are linked with an increased risk of loss of overall physical function in older adults (Balfour et al. 2002). People who live in areas where it is not safe to walk might spend a lot of time indoors and experience higher rates of loss of lower-extremity function.

As researchers find better health interventions to help older adults manage disabling diseases, other aging related problems may manifest and affect their ability to perform daily activities. As the older adult population continues to live longer, they are at increased risk of experiencing functional limitations. Research has shown that there is a causal relationship between physical function and disability in that declines in physical performance occurs before disability. Physical function can be measured using self-reported measures or physical performance tests. Mayhew et al (Mayhew et al. 2020) conducted a study to examine the association between self-reported and performance-based measures of physical function and disability using 51,338 participants from the Canadian Longitudinal Study on Aging. Disability was assessed using ADL/IADL. Participants were considered to have an ADL/IADL disability if they needed assistance to complete at least one ADL/IADL task. Self-reported function was measured using 14 questions adopted from several older adult studies such as the Framingham Disability Study, Established Populations for Epidemiologic studies of the Elderly Study, the Disability of Arm, Shoulder, and Hand questionnaire, questionnaires developed by Nagi, Rosow and Breslau. Physical function was divided into three domains; upper body, lower body and dexterity-related tasks. Performance based functional limitations were measured using a 4-mile test, timed up and go, single leg stance, chair rise test, and grip strength test. The prevalence of self-reported physical function limitations was almost 50 percent and was consistent with Nagi's Disablement Model suggesting that functional limitations occur before disability (Mayhew et al. 2020) . Self-reported functional limitations and disability were high in women when compared to men and increased in all age groups. The study found that both self-reported and performance based physical function limitations were significantly associated with ADL and IADL disability. Individuals with limitation in at least one domain had 3.75 (95% CI: 3.20-4.40) greater odds of ADL/IADL disability compared to those without functional limitations. An increase in number of functional limitation leads to an increased risk of disability (Mayhew et al., 2020). As seen in this study, physical function is an important component of disability related issues. Helping older adults maintain better physical function as they age will help prevent or delay disability.

Disability plays an important role on the quality of life one possesses. It can affect how one views life and interacts with their surroundings. Measurement of disability includes the ability or inability to perform a function taking into account the difficulty of performing that particular function as well as the ability to perform without any additional assistance. Long term, large scale national studies make use of the following instruments to measure disability:

- Activities of daily living (ADL) - skills required to take care of oneself such as bathing, toileting, eating, and dressing
- Instrumental activities of daily living (IADL) – skills required in order to maintain autonomy such as being able to cook, do shopping, manage finances and use communication devices.
- Physical function - Ability to move around freely including climbing stairs, walking at least 0.25 miles, stand or sit for prolonged periods, stoop, bend/kneel, grasp objects and move objects around. Limitations experienced doing any of the above activities might be due to an underlying and may predict one's capacity to participate in certain occupations.
- Cognitive functions – Includes executive, memory, visuospatial, language etc (Health and Disability in the Working-Age and Elderly Populations - Aging and the Macroeconomy - NCBI Bookshelf, n.d.).

Disability is not a permanent condition; it illustrates a relationship between a person and his/her environment. It occurs when a gap exists between personal capacity and environmental demand for a particular activity. It is experienced when someone is having difficulty in doing activities in any domain of life (ADL, IADL, and job) due to health or physical problems. Several things affect the pattern of change and the pace to which someone can experience a disability. Demographic, social, lifestyle, behavioral, environmental and physiological factors can predispose one to disability. Disability can be reduced by either increasing capacity or reducing demand (Health and Disability in the Working-Age and Elderly Populations - Aging and the Macroeconomy - NCBI Bookshelf, n.d.). The presence of disability can interfere in someone's ability to participate in activities required to care for themselves. This can lead to further frustrations, low level of energy and loss of independence and functional capacity.

1.2. Fatigue and Fatigability

1.2.1. Definition, Prevalence and Measurement of Fatigue and Fatigability

Fatigue is a common phenomenon that is characterized by subjective experience of tiredness and/or lack of energy (Rose et al. 2017). It can be experienced by the chronically ill and in the general population. It can range from mild to severe and some people experience it more often than others such that it begins to interfere with their daily activities and affect quality of life(Rose et al., 2017). The global prevalence of fatigue is around 7% - 45% and varies widely due to research methods. It was noted that the prevalence of fatigue might be underestimated because some fatigue complaints are either not reported to the primary physician or the physician doesn't record it (Bensing et al., 1999). Fatigue can result from underlying medical problems but it could also be unexplained. Due to lack of substantial research, those who suffer from unexplained fatigue could feel neglected and frustrated (Yoo et al., 2018). Fatigue can be measured using self-reported questionnaires. Measuring fatigue can be very challenging because the definitions of fatigue vary and there are several instruments which can be used to measure it. When performing certain activities, participants can also reduce intensity in order to remain at a comfortable level. This is something that current fatigue measures cannot pick up and thus lead to bias prevalence rates because self-reported measures are subjective (Simonsick et al. 2014). For example, two older adults may report the same level of fatigue over the past week during an examination. But after an examiner continued to probe both participants, the examiner discovered that one participant lives an active lifestyle while the other has a sedentary lifestyle with several functional limitations (Eldadah 2010). Due to lack of one standardized questionnaire or method of measuring fatigue, other researchers started exploring a new concept of fatigability.

Fatigability is defined as a relationship between self-reported fatigue and the activity demand with which fatigue is associated (Schrack et al. 2020; Eldadah 2010) . It increases with age and may occur as a result of age related declines in physiological functioning or due to functional disabilities that decrease efficiency (Eldadah, 2010). Fatigability allows researchers to objectively quantify fatigue and measure the degree of fatigue experienced as a result of performing a standardized activity or a deterioration of performance while performing a standardized activity (Simonsick et al. 2014). Results from the Long Life Family Study showed prevalence of higher perceived physical fatigability to be around 42% for ages between 60 – 108. When looking at age stratifications, those who are much older (90-108 years) experienced higher level of physical fatigability (around 90%) when compared to the younger age group of 60-69 years whose rate was around 28% (LaSorda et al. 2020).

Fatigability can be measured as perceived fatigability or performance fatigability (Eldadah, 2010; Schrack, Simonsick, & Glynn, 2020). Perceived fatigability measures an individual self-reported feeling of tiredness as a result of performing a particular activity while taking into account the duration of the activity (Eldadah, 2010; Schrack et al. 2020). This could be done by measuring Rating of Perceive Exertion immediately after performing a standardized walk test (Simonsick et al. 2014). One could also use the Pittsburgh Fatigability Scale (PFS) by asking participants to rate the level of physical fatigue they imagine they would experience after completing certain activities taking into account the duration and intensity of that activity (Glynn et al., 2014; Schrack et al. 2020) Performance fatigability is measured by assessing deterioration in performance while performing a certain activity such as a treadmill test or a 6-mile walk. Performance deterioration is defined as either inability to complete or slowing down during a fast -paced walk (Schrack et al. 2020). Measuring deterioration of performance during a standardized physical activity can be a bit challenging as it requires one walk a considerable amount of the set test parameters. As individuals age, some experience physical limitations which limit their mobility and makes it difficult to participate in any form of physical activity. This measurement will be only applicable to those who have no mobility issues. The lack of a unified calculation of performance fatigability makes it challenging to draw comparisons from various cohorts. Perceived fatigability measures whole body fatigue while taking into account the intensity and duration of the activity and does not necessarily require one to be able to complete a certain standardized task, making it more applicable to those with and without mobility issues. Perceived fatigability scores consists of a wide range of values, but performance fatigability usually produces a dichotomous assessment which makes it difficult to quantify (Schrack et al. 2020).

1.2.2. Association of Physical Function with Fatigue and Fatigability

Fatigue is very common among older adults and is considered one of the most important risk factors for disability, and loss of physical function. A prospective study (Mueller-Schotte et al. 2016) was conducted from two different cross-sectional studies with a sample of 534 participants between ages 40-79. The authors wanted to examine whether self-reported fatigue is a long-term risk factor for limitations in instrumental activities of daily living and/or mobility performance in older adults after a period of 10 years. Fatigue was measured using a short form, SF-36 (SF-36 QUESTIONNAIRE, n.d.), in men while a question on general history was used for women. Instrumental Activities of Daily Living (IADL) was measured using Stanford Health Assessment Questionnaire (Bruce & Fries, 2003) at baseline and a modified KATZ-15 ADL/IADL questionnaire (Katz Index of Independence in Activities of Daily Living (ADL), n.d.) at follow up. Mobility was assessed using a 6-min walk test. Sedentary lifestyle among older adults is associated with increased level of fatigue. Males who reported fatigue walked on average 39.1 m less when compared to those who did not report fatigue at baseline (P=0.048). Fatigued women walked on average 17.5 m less than those who were non-fatigued (p=0.479). Females had a much higher prevalence of fatigue (28.1%) when compared to males (18.6%). Self-reported fatigue at baseline was associated with IADL-limitations and mobility performance among males (Mueller-Schotte et al., 2016).

According to Moreh et al (Moreh et al. 2010), prevalence and incidence of fatigue tend to increase as age increases independent of any diagnostic condition. Fatigue was associated with loneliness, depression, low physical activity, chronic back or joint pain, poor sleep satisfaction, self-rated health and activities of daily living. It was also associated with lower survival rate over the 18 years of follow up. Fatigued individual survival rate was 70% compared to 81% of non-fatigued participants. As age increases, fatigue was strongly associated with increased mortality rate and a higher likelihood of subsequent decline in health and levels of physical activity, functional status and depression. Fatigue plays a crucial role in predicting subsequent deterioration of health and functional status (Moreh et al., 2010).

Unresolved fatigue could lead to loss of wages due to absenteeism from work, burnout, and mental and physical exhaustion which could result in health disturbances (Rose et al. 2017). If left untreated, an individual could become less energetic, less focused and unable to properly execute daily activities. This might eventually lead to the diagnosis of chronic fatigue syndrome characterized by fatigue lasting more than 6 months which is not relieved by rest (Yoo et al., 2018). There is vast amount of research to highlight the fact that high levels of fatigue are associated with increased likelihood of various medical conditions. People who are severely fatigued might not have the energy to stay active and participate in activities that maintain better physical function. Reduced physical function may lead to an increase risk of disability among older adults. Fatigue has to be taken very seriously, especially among the elderly in order to improve quality of life and encourage them to move more to reduce limitations associated with aging and loss of physical function.

The ability to execute daily activities is crucial and requires one to be independent and stay healthy for a long time. Other factors that influence fatigue levels are gender and socio-economic status (SES). In most homes, women are still responsible for doing basic chores such as cooking, cleaning and taking care of the children. In addition to these responsibilities, women these days are provided with opportunities to enter and compete in the same work space as men. Despite being considered equal with men in the modern world, women still find themselves continuing to work extra hard while trying to balance work with taking care of their families. This could potentially put more stress on women leading to more fatigue, less physical activity and other health problems.

Previous research had shown that higher levels of fatigue are experienced by those from low SES. However, when taking into consideration the interaction of ethnicity and social classes, the results might be different. A study (Bardwell et al. 2006) was conducted to determine whether ethnicity and social class interacted to explain fatigue. The study had a total of 104 participants, with 64 Caucasians Americans and 40 AAs. The sample completed a multidimensional fatigue inventory (MFSI-SF) as well as a short form of Profile of Mood States (POMS-SF). Hollingshead

(1958ab) Two-Factor of Social Position (Hollingshead, 1975) was used to classify participants into high-middle and low social classes based on their occupation and education.

It was reported that fatigue differed by class among African Americans (AA) but not in Caucasians. Social class is an important predictor of fatigue in AA communities but not among Caucasians. The level of fatigue was double among AA in the upper-middle class when compared to AA in the lower class. AA in higher social class also reported high levels of fatigue when compared to Caucasians. Lack of similar opportunities in society makes it difficult for higher SES AA to compete with their Caucasian counterparts. AAs in the same career fields as their counterparts may have to work even harder to attain the same SES status and this may lead to increased fatigue and other poor health issues (Bardwell et al., 2006). Hudson et al (Hudson et al. 2016) argued that AAs in higher social class are most likely to use prolonged high-effort coping mechanisms when they encounter psychosocial stressors. They may apply a lot of pressure on themselves in order to achieve success, by working extremely hard in order to overcome structural and person mediated discrimination. These coping strategy may be harmful to their health (Hudson et al. 2016).

Fatigability is considered as an early and sensitive biomarker of physical functional limitations, therefore disability. Martinez-Amezcua et al (Martinez-Amezcua et al. 2018) conducted a cross sectional study to examine the association of fatigability and functional performance among older adults with low-normal ankle brachial index (ABI). The sample consisted of 570 adults aged 50 and older from the Baltimore Longitudinal Study of Aging (BLSA). Physical function was measured using a long-distance corridor walk (LDCW) which is a two-faced, self-paced endurance walking test. The first phase of the test was used to assess walking endurance and participants are asked to walk for 2.5 minutes at their usual pace. The second phase measured cardiorespiratory fitness and required participants to complete 10 laps (400 meters) as quickly as possible.

Physical performance was measured using the Health, Aging and Body Composition Physical Performance Battery (HABC PPB). This test measures the ability and time to complete 10 chair stands, 3 progressively harder standing balance poses, timed 6-m walk at usual gate speed, and timed narrow 6-m walk test. Fatigability was assessed immediate after a slow-paced standardized treadmill walk. Participants were asked to rate their perceived exertion using the Borg rating of perceived exertion. Systolic blood pressure was measured using an automated testing device. The study found that lower ABI values were associated with high level of fatigability and poorer physical functioning. Early changes in ABI may suggest an increased risk of functional decline and thus disability in a long run (Martinez-Amezcua et al. 2018)

During the validation of the Pittsburgh Fatigability Scale (PFS), Glynn et al concluded that fatigability was strongly associated with slow gait, lower fitness and worse physical function($P<0.001$) (Glynn et al., 2015). Later, Simonsick et al (Simonsick et al. 2018) evaluated the PFS as a predictor of performance and function in mobility-intact older adults from a longitudinal BLSA study. There were 579 participants, males and females between the age of 60 – 89. The participants completed the PFS at baseline and follow-up sessions were completed biannually for those who are 60-79 and annually for the older participants, 80 and older. At baselines, participants had to be free of functional limitations, cognitive impairment and major chronic disease. Physical performance and function were assessed using 6-m course with participants asked to walk at their normal pace. Participants also performed repeated chair stands and their walking ability index was measured using a self-reported questionnaire asking participants if they are able to walk a quarter of a mile taking their health into account. Higher physical fatigability score from the PFS was associated with significant decline in usual gait, chair stand pace, and reported walking ability (all $p<=0.009$) (Simonsick et al. 2018).

Urbanek et al (Urbanek et al. 2018) examined the association between accelerometry-derived gait characteristics with common measures of physical function, mobility, fatigability and fitness in order to validate the novel gait characteristics during sustained harmonic walking. The sample consisted of 89 community dwelling older adults from Pittsburgh, Pennsylvania area for the national Institute on Aging, Aging research Evaluating Accelerometry project. Participants wore actigraphs on their right hip in the lab and in the wild experiments (outside uncontrolled environment). During the in the lab experiments, participants wore the actigraphy during a 4-m walk and two 400m walks. Participants were also given actigraphs to wear outside of the lab while maintaining their normal lifestyle for seven consecutive days but took off the device during sleep. Physical function was measured using the Short Physical Performance Battery (SPPB). Mobility was evaluated using the fastest of two usual paced 6-m walking tests from the SPPB. Fitness was considered as time to complete a fast paced 400-m walk. During the outside lab experiment, features of walking were highly correlated with fatigability. Median walking acceleration observed during outside walking was strongly correlated with physical function (Pearson $r=0.46$, $p<0.001$)

and fatigability (Pearson r=-0.55, p<0.001). Among healthy older adults, accelerometry-derived features of sustained harmonic walking are strongly associated with measures of physical function, mobility, fatigability and fitness (Urbanek et al. 2018).

Simonsick et al (Simonsick et al. 2016) conducted a longitudinal study to examine perceived fatigability as a predictor of meaningful functional decline in non-mobility limited older adults. The study consisted of 540 men and women ages 60 – 89 participating in a Baltimore Longitudinal Study of Aging. The participants had to report no difficulty in walking for a quarter mile and had perceived fatigability and functional assessment at baseline and follow-up functional assessment one to three years later. Perceived fatigability was measured using the Borg rating of perceived exertion (RPE) immediately after walking for 5 minutes on a treadmill at 1.5 miles per hour with 0 percent incline. Participants were not allowed to hold on the treadmill handles except as a safety precaution. Physical function was measured using a 6-meter course and participants were asked to walk at their normal pace for two trials and then as fast as they could for two trials. Besides walking a 6-meter course, participants were also asked to preform chair stands on an armless chair five times, and three progressive balance tests with each test lasting up to 30 seconds. Walking ability was determined using a self-reported questionnaire where participants were asked whether they had any difficulties walking a mile using a scale of 0 (unable to walk) to 9 (walking one mile is easy. A unit increase in fatigability was associated with a 13 to 19% increase odds of meaningful decline in gait speed, physical performance and walking ability (p=0.002 to 0.02) (Simonsick et al. 2016).

As the literature showed above, fatigability and fatigue are both strongly related to physical function. Research has shown that limitation in functional abilities is associated with an increased risk of disability. Interventions that target physical function are more like to reduce or delay disability. Physical activity may be a promising intervention that could help older adults age well with less disability and improve physical function.

1.3. Physical Activity

The prevalence of insufficient physical activity (PA) globally was 27.5% in 2016 (Guthold et al. 2018). Physical inactivity among adults was defined as not meeting the World Health

Organization (WHO) recommendations of at least 150 minutes of moderate physical activity or 75 minutes of vigorous intensity physical activity per week (Guthold et al. 2018). The prevalence of insufficient PA in countries with high income is double the rates of low-income countries. It is possible that the advancement in technology and the availability of more modern conveniences may have led to increasingly sedentary lifestyles. Many individuals from high income countries drive to get from place to place but walking is the most common and affordable way of getting around in low-income countries. The prevalence of physical inactivity hasn't changed much between 2001 (23.4%) and 2016 (27.5%) (Guthold et al., 2018). Physical inactivity is one of the risk factors for non-communicable disease and physical disability and has negative effects on quality of life and mental health.

Around 28-34% of American adults between the age of 65 and 74 are physically active, and among those who are 75 and older, 35-44% are physically active (Watson et al. 2016) . According to the Center for Disease Control and Prevention (Anon n.d.), the overall prevalence of physical inactivity in the US is more than 15 percent. Physical inactivity was defined in this context as self-report of engaging in no leisure-time physical activity during the past month. People are asked the following question telephonically during a survey, "During the past month, other than your regular job, did you participate in any physical activities or exercises such as running, calisthenics, golf, gardening, or walking for exercise?" Those who respond "no" are considered not physically active. The prevalence of physical inactivity among non-Hispanic blacks was 30.3% compared to 23.4% among non-Hispanic whites. As shown in figure 1, non-Hispanic blacks had higher prevalence of physical inactivity in most of the states when compared to non-Hispanic whites between 2015 – 2018 (Anon n.d.). Racial and ethnic differences of physical activity levels may be affected by education, socioeconomic status time constraints, geographical location and health disparities (Saffer et al. 2013) . A study (Carlson et al. 2018) was conducted to examine the effect of physical activity on mortality in the USA found that physical activity was strongly associated with mortality for adults aged 40 and above ($p<0.001$). Around 9.9% of death for those between 40 and 69, and 7.8% for those aged 70 and older was associated with lower level of physical inactivity (Carlson et al., 2018).

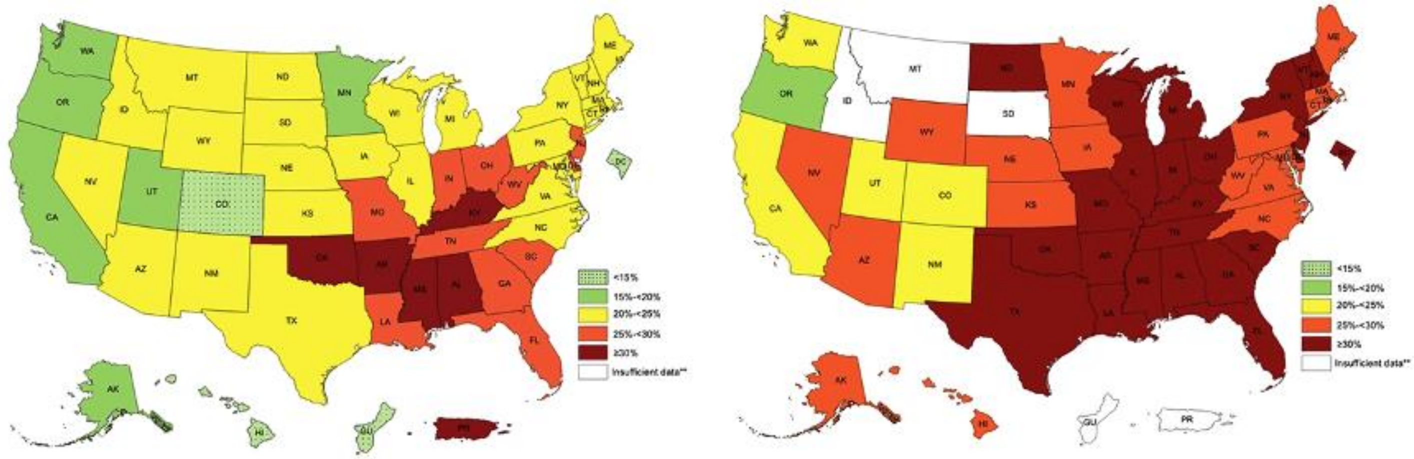

Figure 1: US prevalence of physical inactivity between 2015 – 2018 by race, non-Hispanic whites (left) vs non-Hispanic blacks (right)
Source: The Behavioral Risk Factor Surveillance System

1.3.1. Physical Activity and Disability

The relationship between PA and disability might be influenced by mobility, which is defined as the ability to walk safely and independently. As people age, mobility might be lost and that will lead to a significant increased risk of disability. Regular PA is strongly associated with higher physical function and good mobility later in life. Patel et al (Patel et al. 2006) conducted a study to assess association between physical activity and mobility in older age. The sample comprised of 1155 adults aged 65 and older living in Chianti, Italy between 1998 and 2000. Physical activity was measured using an interviewer administered questionnaire where participants were asked to indicate their average level of PA during three age period: 20 to 40 years, 40 to 60 years and the past year. Mobility was assessed using the Short Performance Battery (SPPB) and a standard 400-meter course. The SPPB includes static balance, walking and chair rise times. The study found that participating in PA in midlife is associated with mobility in older adulthood. Older Italian adults who reported moderate to vigorous physical activity in midlife enjoyed much better mobility in old age when compared to those who reported very low level of participation in physical activity (Patel et al., 2006) . Regular participation in PA leads to good mobility later in life which might lead to a reduced risk for disability. Besides improved mobility, PA has much more benefits including better physical function which can lead to improved quality of life among older adults.

To understand this relationship, one has to understand the role that physical activity plays in preventing disability. Walking is a required to maintain one's functional independent as aging approaches and it is one of the simplest forms of physical activity. Paterson et al (Paterson and Warburton 2010) conducted a systemic review to examine the relationship between physical activity and health outcomes of functional limitations, disability, or loss of independence among community dwelling older adults between ages 65 and 85. Sixty-six prospective cohort studies met the inclusion criteria for the relationship between physical activity and functional independence. The measurement of functional outcomes included functional status, decline, impairment or functional limitations, or disability or measured physical performance tests. PA categorization varied as some studies quantified PA by volume (as a total expenditure, or frequency and duration of activities, while others accounted for relative intensity of the activity (light, moderate and vigorous) and types of activities (walking, exercising, sports, play, recreational, household chores). Greater amount of physical activity predicted higher functional status. Individuals who are physical activate have reduced risk of disabilities associated with ADLs or IADLs or level of disability. Participation in regular moderate to higher level of physical activities was found to be effective in preventing functional limitations and disability. PA is protective against the development and progression of disabling conditions and enables older adults to remain independent or delay functional limitations associated with aging. Improved aerobic capacity, muscle strength, and flexibility has been attributed to contributing factors of physical activity on delaying or preventing disability. It is recommended for older adults to participate in moderate to high intensity physical activity with a total weekly volume of 150 – 180 min/week (3 hours at moderate pace or 2.5 hours of more vigorous brisk walking or other types of aerobic activities. Participating in these kinds of physical activity would translate to a more than 30 percent decrease in the relative risk of morbidity, mortality and loss of independence (Paterson and Warburton 2010).

1.3.2. The association between Physical Activity and Fatigue and/or Fatigability

According to the center of disease control (Lack of Physical Activity | CDC, n.d.), 1 in 4 US adults are physical active. Lack of PA is associated with increased risk for a lot of chronic diseases and can lead to high financial costs. A lot of literature agrees that regular physical activity is beneficial to our physical and mental health among all ages. Aging comes with a lot of challenges that lead to several physiological changes that affect how we interact with the world around us. One of those changes include slow gait which occurs due to a compensatory mechanism used by older adults to conserve energy and reduce fatigue associated with walking. Research suggest that energy needed during walking may play a crucial role in the development of mobility limitation in older adults. Deterioration of aerobic capacity may be responsible for slow walking speed and higher level of fatigability (Richardson et al. 2015). The Study of Energy and Aging pilot found that greater fatigability measured using situational Fatigue Scale was associated with higher rates of energy expenditure during walking among older adults aged 70 - 89. When compared with fast walkers, slow walkers had reduced aerobic capacity which was reflected by lower VO2peak values. Slow walking was also associated with greater fatigability on a situational fatigue scale and higher perceived exertion at the end of walking tests. No fatigue differences were observed between fast and slow walkers. Individuals who walk slower may intentionally do so to reduce the energy requirement during walking in order to remain in a comfortable state. This however makes it difficult for researchers to study and understanding the mechanism associated with age related slow gait which may contribute to limited mobility and disability among older adults (Richardson et al., 2015).

Schrack et al (Schrack et al. 2012) studied the role of energy cost in the age-related slowing gait speed using 420 community dwelling individuals who are aged 32 – 96 from BLSA. Gait speed was assessed by asking participants to walk at their usual pace over a 6-meter course in a corridor. Energy expenditure was measured using indirect calorimetry (Cosmed k4b2, Cosmed, Rome, Italy) during 2.5 minutes of overground walking. During the test, oxygen and carbon dioxide were continually collected and analyzed with every breath measurement. The average energy expenditure per minute during traditional walking on a flat course was 13.0 m1/kg/min regardless of age. This further bolster the idea that older adults slow down to maintain their desirable level of fatigue and conserve energy. When faced with age related limitations, older adults intentionally slow down to reduce energy expenditure. The presence of certain conditions such as diabetes and balance difficulties when walking may play a crucial role in explaining these compensatory mechanisms in older adults (Schrack et al. 2012).

As people age, the body undergoes a physiological process of slowing down in some areas including physical conditioning. In some research studies, fatigue has been blamed for contributing to a reduction in physical activity levels among older adults. As mentioned before, measuring fatigue varies among researchers making it difficult to evaluate the causal association between fatigue and PA.

Wanigatunga et al (Wanigatunga et al. 2018) evaluated the association of perceived fatigability and objective physical activity in mid to late-life. The study consisted of 770 males and females from BLSA between ages 50 – 94. Perceived fatigability was measured using rate of perceived exertion immediately after a 5-minute treadmill walk at 1.5 mph with 0% incline. Daily physical activity was measured using an Actiheart monitor positioned across the chest. Participants were instructed to wear the device for seven consecutive days. After controlling for demographics, every unit increase in perceived fatigability was associated with 1.3% reduction in total daily physical activity. Higher perceived fatigability was associated with lower overall daily physical activity especially between 8am and midnight. Higher level of perceived fatigability observed with advanced aging significantly contributes to lower levels of physical activities among older adults (Wanigatunga et al. 2018).

The Lifestyle Interventions and Independent for Elders (LIFE) prospective study (Glynn et al. 2020) assessed the impacts of baseline fatigue on the effectiveness of a physical activity intervention to prevent major mobility disability among older adults aged 65 and older. Fatigue was measured using a modified trait version of the Exercise-Induced Feeling Inventory. Participants walked 2 times per week with the goal of 30 minutes/sessions at a rating of 13 using the BORG Rating of perceived exertion. PA frequency gradually increased to 3 – 4 sessions per week and included strength training, flexibility and walking with weights. The study found that long term moderate intensity physical activity was effective at preserving mobility in older adults with higher levels of fatigue at baseline. Those with higher level of fatigue at baseline and were assigned to physical activity had a 28% reduction in major mobility disability compared to 18% reduction of those who were in the health education group and had higher fatigue measures at baseline (Glynn et al., 2020).

Soyuer et al (Soyuer and Şenol 2011) conducted a study to examine physical activity habits and prevalence of fatigue among older adults who are 65 years and older and live in rest homes. They only included individuals who were able to perform daily routines without any assistance, and had the ability to communicate. Fatigue severity scale was used to measure fatigue and physical activity was measured using the Physical activity questionnaire, CHAMPS. Increased levels of fatigue were associated with lower levels of physical activity among older adults ($p<0.00$, $r=-0.263$). Fatigue is usually found in the elderly whose activities are limited, and it was also stated that it may result from being incapacitated (Soyuer & Şenol, 2011). Participating in physical activity among the elderly population can help reduce disease, disability and the negative effects of aging. It is imperative to encourage the elderly to participate in physical activity in order to help improve their quality of life and reduce early manifestation of disease. Society has to do better by providing space in homes or community centers for the elderly to freely and safely participate in PA.

Puetz (Puetz 2006) conducted a literature review of studies assessing the association between physical activity and feelings of energy. Results showed a positive association between physical activity and a reduction in risk of experiencing feelings of low energy and fatigue. Physically active adults had a 40% reduced risk of experiencing feelings of low energy and fatigue when compared with those with sedentary lifestyles. Participation in regular physical activity is recommended for good physical and mental health (Puetz, 2006). Participation in regular physical activity is also highly associated with improved mood and reduced level of fatigue.

Fatigue associated with cancer and its treatment is a very common phenomenon even beyond treatment. Cancer related fatigue is different from the normal fatigue experienced by healthy individuals and present differently in that it can be chronic and less likely to be relieved by rest. Twomey et al (Twomey et al. 2018) looked at the differences between general traditional exercise and tailored exercise intervention (12 weeks) to reduce fatigue in cancer survivors through a randomized controlled trial. The study recruited 52 male and female cancer survivors aged 18 – 75 years after a recent cancer diagnosis of any kind between 2013 - 2016. As part of screening, participants also completed FACIT-F questionnaire and those who received a score of above 34 were in the trial. Participants were randomized to their preferred group with a 1:1 allocation ratio and a randomization weighting of 0.75 to help avoid bias. The assessment of cancer therapy was measured using general FACT-G. Researchers also collected information on depressive symptoms using Center for Epidemiological Studies and Depression, Pain (Brief Pain Inventory Short Form), social provisions (Social provision Scale), and leisure-time exercise (modified Glodin Leisure Time Exercise Questionnaire). Researchers also collected blood samples, body composition and mineral density (dual energy x-ray absorptiometry), grip strength measurements, neuromuscular assessments (powerLab), cancer related fatigue (FACTIT-F) and VO2 max (recumbent ergometer). Physical activity data was collected using actigraphy for 15 consecutive days. Participants in the traditional group performed the recommended 150 minutes of aerobic moderate intensity while the tailored exercise group attended classes three times a week (60 – 90 minutes) to address areas of deficits identified in the lab during baseline sessions. There is evidence to support both traditional and tailored interventions are beneficial to cancer patients but a tailored program targeting distressing symptoms is recommended for cancer survivors. A tailored program can also help reduce adverse event occurrences as it takes into account the participant's medical condition (Twomey et al. 2018).

The relationship between physical activity and fatigue/fatigability is two way. Higher level of fatigue or greater fatigability can lead to avoidance of physical activity resulting in loss of physical function associated with aging. Older adults may continuously reduce their physical activity level and intensity in order to preserve their energy thus making them more inactive. Low level of physical activity leads to reduced aerobic capacity and give rise to mobility issues and difficulty in maintaining functional status with aging. This also result in high level of fatigue and physical fatiguability. African Americans have some of the highest rates of physical inactivity compared to other races and this further contributes to existing health disparities experience by this underserved population. Regular participation in physical activity can help older adults remain energetic, maintain independence and physical function in order to prevent aging related health conditions.

1.3.3. Barriers to Physical Activity

Physical activity has emerged as a low-cost method for improving healthy lifestyle in older adults (Tuso 2015; Taylor 2014) . When people stop exercising, the long-term consequences can be severe and limit their ability to move around freely and participate in activities to activities of daily living. The benefits of PA have shown to reduce risk of disease and improve overall wellbeing among other things. Even with all of these promising benefits, previous physical activity interventions do not have enough African Americans (AA) in their samples. This makes it difficult to determine whether PA interventions can produce the same results among minorities. Recruitment and retention of AA in research is very challenging, resulting in them being underrepresented in PA studies. The knowledge of the benefits of PA does not translate to participation in physical activity. Barriers to PA among AA communities include lack of social support, safety concerns, lack of motivation, mistrust of researchers, lack of interest, lack of sidewalks, cost and often unavailable exercise facilities, and low energy (Joseph et al. 2015). A history of racial discrimination and exploitation of AA continues to contribute to low numbers of AA in clinical research. Getting someone to begin participating in physical activity will take more than encouragement. Addressing these barriers will be a crucial first step.

As older adults continue to survive and live longer, researchers have to find ways to help them deal with aging related health issues. Many older adults lose their ability to perform important daily activities independently. Rapid population growth and an increase in sedentary lifestyle among the elderly will lead to several aging related health issues. Researchers are challenged to find more entertaining forms of PA in order to help the elderly age successfully and not lose their functional capacity too quickly. Regular PA is known to offer substantial benefits to one's physical and mental health. However, starting and finishing any PA program will require one to enjoy what they are doing and also trust the people they are working with. The initiation of any PA program can be very challenging, so does its continuation. Some researchers have been exploring whether dance can be used as a form of a physical activity that is beneficial to one's mental and physical health. Dance interventions might provide the excitement and enjoyment that normal physical activity programs do not offer. Providing a more culturally sensitive PA intervention can help improve adherence and maintain high level of PA in underserved communities (Stillman et al. 2018) .

1.3.4. Dance

The use of dance as an attractive form of physical activity is on the rise and is seen as a way to improve intervention adherence rate. A lot of dances can be modified to fit the target group and help reduce safety concerns, especially for sedentary older adults when initiating an intervention. Dance interventions may be considered safer and accessible exercise programs for the elderly. A systematic meta-analysis review (Rodrigues-Krause et al. 2016) was conducted to assess the effects of dance interventions on cardiovascular risk (CVR) in older adults. The author included both randomized control trials and non-randomized control trials as well as other types of exercise. There was an improvement in VO2 Peak among dancers whose mean age was over 60 compared to non-exercise controls (3.4mLkg^{-1}, 95%CI: 1.08, 5.78). Dance is as effective as other types of exercise in improving aerobic capacity among older adults. Improvement in cardiovascular fitness is associated with a reduction of cardiovascular risk factors and coronary heart disease (Rodrigues-Krause et al., 2016).

A randomized control study (Hopkins et al. 1990) was conducted to examine functional fitness changes associated with a low-impact aerobic dance mode of physical activity. The authors used a collection of various dances to form a choreography which was performed to music. All dance moves were performed with at least one foot on the ground at all times. There were 65 participants (women) between ages 57-77 who lived in the community and had not exercised regularly in the past year. 35 participants were randomly assigned to the dance intervention while the other 30 were placed into the control group. The control group were asked to continue with their usual activity but would be allowed to participate in the dance program at the end of a 12-week intervention. Cardiorespiratory fitness was assessed using a half-mile walk test where participants were told to walk as fast as they could without running. The functional fitness of those in the control group continued to decrease while improvement was seen among those who were in the dance intervention. It was concluded that a low-impact dance intervention can be used to improve functional fitness among sedentary women (Hopkins et al., 1990).

Flores et al (Flores 1995) studied the impact of Dance for Heath intervention on improving aerobic capacity, helping students maintain or decrease weight, improve attitudes and physical activity and fitness among AA and Hispanic school adolescents. The Dance for Health intervention included a culturally sensitive health education curriculum and was compared to normal school physical activity consisting of mostly playground activities. The dance group attended 50-minute sessions, three times a week while the other group only participated in two sessions per week. Dance for health was effective in providing enjoyment, improving fitness and reducing weight among Hispanic and AA girls. The implementation of a culturally-sensitive physical activity program was very effective for underrepresented minorities (Flores, 1995).

Aerobic dance is a form of PA that involves the use of major muscle groups in a continuous rhythmic movement and combines aerobic movements, muscle building and stretching routines. It can be used to encourage regular participation in exercise while providing enjoyment and health benefits similar to those obtained from an aerobic workout. The implementation of a structured aerobic dance can be enough to stress the cardiorespiratory system if the intensity is between 50 – 80% of the VO2 max (Akinyemi 2017). A quasi-experimental study was conducted in Lagos, Nigeria to determine the effects of Indigenous Aerobic Dance music on physiological variables of female workers. 47 females between 46-55 years old were divided into two groups and participated in a training program three times a week for a period of eight weeks. 23 females participated in indigenous aerobic dance while 24 were in the control group. The dance group performed exercises for about 30-40 minutes at 60-80% of their maximum heart rate. Heart rate, and blood pressure were measured before and after the session. A reduction in blood pressure and resting heart rate was observed among those in the dance group while the control group showed increased resting blood pressure. Aerobic dance performed within a targeted heart rate between 60-70% of maximum heart rate has proven to provide cardiovascular and metabolic benefits such as increased maximal oxygen consumption and improvement in aerobic endurance capacity and energy production (Akinyemi, 2017).

Aerobic exercise plays a crucial role in managing fatigue. High level of aerobic capacity is associated with reduced level of fatigue. Participating in regular physical activity has been shown to have substantial health benefits that might help older adults manage aging successfully. Dance can be used as a form of aerobic exercise and thus can lead to reduced fatigue, improvement in functional capacity and quality of life. Among AA, dance is symbol of African tradition and brings a sense of community to those who participate in it. An 8-week quasi-experimental design was used to assess the effect of a culturally sensitive dance intervention on functional capacity among AA women who attended church service in their respective home church. There were 126 participants between ages 36 – 82 years. The participants attended two 45-minute sessions per week for a period of 8 weeks. The dance group improved their functional capacity which was defined as being able to walk for a distance which is associated with the ability to do normal daily activities such as shopping, caretaking and domestic activities (Murrock and Gary 2008). Improved physical functional capacity allow older adults to freely participate in PA and also lead to reduced level of fatigue. Dance can be used to increase adherence to a physical activity program among those who would otherwise not be keen to exercise. The importance of PA has led researchers to look for more exciting alternatives to regular physical activity and dance seems to be one of the most promising options.

In Africa, music and dance are integrated into every area of one's traditional life starting from birth to death. It is an essential component of culture and dance movement is designed to mimic everyday activities. It is more than just physical activity; it also serves as a spiritual ritual which has psychological benefits (Ijeoma, 2006). Despite Africa's diversity, it's rich cultural practices such as dance, music and oral traditions are common ways of artistic expression practiced all over the African continent and connect it's people regardless of where they are (Franklin, 2013). The popularity of African dance among AA communities has been on the rise and is heavily promoted. Since dance is imbedded in African culture, to dance is to connect with the ancestors, to heal and immerse oneself into the deep cultural roots of Africa. This serves as a great tool for AA to reconnect with their heritage or history.

The use of a culturally sensitive forms of PA, African dance, among AAs will motivate and help them explore and connect with their ancestral African roots. To some, dancing serves as a therapeutic tool and help reduce anxiety and depression. If structured well, African dance can serve as a way to keep people physically engaged at various intensities, depending on their age.

1.4. Gaps in Knowledge

Sedentary lifestyle and low level of physical activity are strongly associated with higher fatigue. Higher level of fatigue observed with advanced aging significantly contributes to lower levels of physical activities among older adults. Many older adults lose their ability to perform important daily activities independently due to low level of physical activity and fatigue and this can contribute to poor physical function and accelerated mortality. Participating in regular physical activity can help reduce disease, disability and negative disabling effects of aging. To address low level of physical activity associated with fatigue, one has to find a better way to measure whole body fatigue to be able to find successful lifestyle interventions.

Fatigability is a newer concept and takes into account the activity being performed as well as the duration and intensity. Glynn's work (Glynn et al., 2015) highlight how fatigability is more sensitive to fatigue but the study does not have enough black participants to enable subgroup analysis for this particular population. The benefits of regular participation in physical activity are known among researchers to reduce risk of disease and improve overall wellbeing among other things. But there are few physical activity intervention studies evaluating the benefits of PA on reducing perceived physical fatigability. Blacks have higher levels of physical inactivity and are underrepresented in lifestyle intervention studies. Other researchers have started using dance as a form of culturally sensitive PA intervention to help encourage participation in physical activity but none have yet evaluated the impact of a dance intervention in reducing perceived physical fatigability. African dance may be an effective culturally sensitive tool to increase participation in regular physical activities in black communities, potentially reducing fatigability (i.e., improving exercise tolerance, and thereby subsequently delaying and/or reducing disability and ultimately enhancing successful aging.

1.5. Public Health Significance

The idea of aging well is embraced by many individuals, but its practicality presents a lot of challenges to some. In Africa, aging puts one at the top of the social hierarchy. Becoming an elder in the community is something that people are excited about and look forward to. This idea has been embraced from generation to generation and it is culturally preferred for young people to care for their aging parents. The grandparents will then impart knowledge and wisdom to their grandchildren. As precious as aging is, it comes with many health-related burdens because some body systems begin to fail. These changes often lead to stressful periods for those who are undergoing it. High levels of mental and physical fatigue can also manifest due to decline in multiple body systems and accelerated aging processes. In older adults, high levels of fatigue may be associated with sedentary lifestyles (Murphy & Niemiec, 2014).

As we continue to see a rapid increase in the aging population, disability and fatigue will continue to trouble older adults. The prevalence of disability is higher in low-income countries and among those with low SES. Most African Americans live in poor neighborhoods and experience worst health outcomes inducing higher rates of disability. Beyond policy related implementations, researchers have to help poor communities to help reduce health disparities. One of the most promising intervention is physical activity, which has been shown reduce fatigability, preserve mobility and improve physical function thus leading to reduced risk of disability and mortality. Most people know about the benefits of PA but still do not exercise. As researchers, we have to find entertaining modes of exercise to help older adults stay fit in order to reap the benefits of successful aging. African dance can serve as a culturally sensitive tool to encourage older AA to get involved in regular PA and maintain an active lifestyle.

2. Objective

The purpose of this study was to examine the effect of a 6-month African dance physical activity intervention on change in perceived physical fatigability in older African American aged 60 – 80 from the Rhythm Experience and Africana Culture Trial (REACT). Since fatigability is a marker of exercise tolerance, we hypothesize that PFS Physical scores will decrease for those in the intervention compared to the control group.

3. Methods

3.1. Overview of the Rhythm Experience and Africana Culture Trial (REACT) Study

The REACT project is a 6-month ongoing NIH funded randomized controlled trial which aims to investigate the efficacy of using African Dance as a form of moderate-intensity physical activity to improve cognitive function in older African Americans aged 60 - 80.

3.2. Recruitment and Eligibility

Participants were recruited from several African American communities in Pittsburgh, Pennsylvania. Several recruitment and advertisement strategies were used including distribution of study flyers at community center and churches, Pitt + me registry, presentation of African drumming in several churches, and word of mouth. A total of 121 participants were screened telephonically at the University of Pittsburgh.

After participants voluntary express interest in the study, they were contacted to assess their eligibility. During the telephone screening, participants were asked about medical history and given a cognitive status test. The inclusion criteria were as follows:

a) have to self-identify as African American or black, b) be between the ages 60-80 c) speak English as a primary language, d) available during the times the classes are offered, e) have reliable transportation to be able to attend classes and assessments, f) score at least 21 points on the Telephone Interview of Cognitive Status (TICS), g) have no history of balance problems or falls, h) have no history of neurological/psychiatric disorders, i) have no history of cardiovascular events such as heart failure, angina or hypertension not currently managed by medication and, j) have no serious cardiac or cardiovascular event in the past 2 years, such as a heart attack or heart surgery

Of those who were eligible, 58 prospective participants consented to the study during the baseline cognitive assessment, and 40 participants were randomized. At the time of this work, 36 participants completed both the baseline and follow-up assessments at 6 months. All participants identified as black or African American and 82.5% of those randomized were females. A total of 20 participants were randomized into the African Dance while the other 20 were randomized into the African Cultural Immersion group.

3.3. Data Collection

Eligible participants were asked to complete four assessments: a cognitive assessment, submaximal VO_2 testing, Magnetic resonance Imaging (MRI) and blood draw at the Brain Aging and Cognitive Health Lab, Department of Psychology, University of Pittsburgh. These sessions were completed before randomization and after the intervention.

3.3.1. Fitness and Anthropometric Assessments

After the cognitive session, participants completed a submaximal VO_2 test on the treadmill. During this session, participant's resting blood pressure and heart rate measures were taken before they started warming up on the treadmill. They were asked to walk on the treadmill at a constant speed but the incline kept increasing every 2 minutes until they reached 85% of their maximum heart rate. During the session, they also wore a heart rate monitor and face mask which was used to collect the air they expired during exercise. In order to estimate their fitness level, peak VO_2 (mL/kg/min) was calculated and recorded. Body mass index (kg/m^2) was also calculated using the measured weight and height.

3.3.2. Senior Physical Function Test

The physical function test was completed right before the fitness assessment and was designed to measure functional fitness among older adults. During this session, participants were asked to perform several tasks including; arm curls, two minutes step test, chair stand and times up and go.

3.3.2.1. Arm Curl

The purpose of this test was to measure upper body strength. The participants were asked to hold a dumbbell (5lb for females, 8lb for males) on their dominant arm. They were instructed to do as many curls as they can in the allocated 30 seconds while seated. The number of curls were recorded after 30 seconds.

3.3.2.2. Two minutes Step test

This test is used to assess physical stamina and endurance. The stepping height for each participant is set based on certain anatomical positions of their leg. Once the distance is set, the examiner marks the height on the walk. The participants had to stand facing the wall and were asked to lift their knees to the appropriate height each time so that the knee is level with the tape mark on the wall. The entire foot must touch the ground on each step to make sure they are not jogging. The examiner counts each time the participant raises the knee, counting each full stepping cycle. A full step cycle is when both feet have lifted off the floor and come back down. The examiner times the participant for 2 minutes and counts the number of steps completed within that timeframe.

3.3.2.3. Up and Go test

The purpose of this test is to measure speed, agility and the ability to balance. The examiner places a cone exactly 8 feet from the chair and the participants is seated on the chair facing towards the cone, with their hands on the thighs, and the feet on the ground with one slightly in front of the other. Once the examiner signaled “go”, the participants rose from the chair and walked as quickly as possible towards the cone. They walked around the cone and returned to the chair as soon as possible. The examiner stopped the watch when the participant was fully seated on the chair. The test was performed twice and the fastest time between the two trials was recorded.

3.3.3. Take Home Questionnaires

Participants were also given a set of take-home questionnaires (THQ) which were used to assess several measures including quality of life, depression, physical activity level, fatigue, physical and mental fatigability.

3.3.3.1. 36-Item Short Form Survey Instrument (SF-36)

SF-36 is questionnaire that is used to measure quality of life. Four questions were extracted from the questionnaire. Participants were asked whether their health had limited their ability to perform certain activities such as walking more than a mile with a scale of 1(yes, limited a lot) to 3(no, not limited at all). A low score indicates greater limitation. They were also asked to rate how much pain had interfered with their normal work (outside of work and home) in the past four weeks using a scale of 1(Not at all)-5(Extremely). A higher score indicates severe limitation. They were also asked whether they have had lots of energy in the past 4 weeks using a scale of 1(all the time) to 6 (None of the time). A lower score on the energy question means they have a lot of energy.

3.3.3.2. Health History/Demographic Questionnaire

Participants completed a health history questionnaire where they were asked if they experienced any history of unusual fatigue with normal activities. They had to respond with either "yes" or "no". Participants were also asked about their history of smoking and years of completed education.

3.3.4. Fatigability Measures

Perceived physical fatigability was measured using a self-administered 10-item Pittsburgh Fatigability Scale which was validated by Glynn et al, 2014. Participants are asked to rate their level of physical and mental fatigue they would expect or imagine they would feel immediately after completing each of the ten listed activities. Although the scale evaluates both physical and mental fatigability, this essay only examined perceived physical fatigability. The rating scale for physical fatigability ranges from 0 (no fatigue) to 5 (extreme fatigue). Participants also had to indicate whether they had performed each of the ten activities in the past month with a yes or no. The PFS scores range from 0 – 50 and was calculated by summing up the scaled fatigue score of each of the 10 items. A higher score indicates greater fatigability. The fatigability scale was dichotomized into two categories with a score of less than 15 indicating low perceived fatigability while a score of 15 or higher indicates higher perceived fatigability. An imputation was used to address missing values if 1-3 items of PFS values (N=2) were missing and only if participants completed a question whether they participated in the activity in the past month (Wasson et al., 2018).

3.3.5. Fatigue Measures

Fatigue was measured using two questions from the self-administered Center for Epidemiology Studies Depression Scale (CES-D) “7. I felt that everything thing I did was an effort” and “20. I could not get going”. Participants were asked to indicate how often they experienced certain feelings and behaviors over the past week. They were asked to check their responses using the following scale: less than one day (rarely or none of the time) = 0 , 1-2 days (some or a little of the time) = 1, 3-4 days (occasionally or a moderate of time) = 2; and 5-7 days (most of the time)=3.

3.3.6. Randomization

After successful completion of the cognitive, MRI and fitness test, participants were randomized into either an African dance class or an African Immersion class. Regardless of group randomization, participants attended one-hour long classes three times a week for a period of 6 months. For those who were randomized into an African dance class, blood pressure and heart rate were taken before and after every class. They were asked to put on the heart rate monitor which was be linked to a Polar app on the iPad to allow intervention stuff to monitor participants heart rate during the session. Blood pressure for the cultural immersion group was also take before and after class but HR was not monitored for this group.

3.3.7. Intervention Class Formats

The participants in the dance group began class with a 5-minute warm up before copying basic movements performed by the lead dance instructor. These movements got more complex as participants progress in the intervention. For the first 2-4 weeks, participants exercised at a very low intensity to allow them to familiarize themselves with the choreography from Guinea and Uganda. After 4 weeks, participants exercised at a moderate intensity, between 60-75% of their maximum heart.

Those who were randomized to the cultural immersion group received vast experience in Africana culture focusing on cooking, education about spirituality, ethnicity, rites of passage, sexuality, social structure from pre-colonial to post-colonial periods, and learning to play African musical instruments. Both groups attended one-hour long sessions three times a week for a period of 6 months.

3.3.8. Data Analysis

Descriptive analysis of continuous and categorical variables was performed using t-test and Chi-squared tests respectively. Fisher's exact was used for those whose cell count in the categorical variables was below five. T-test was used to assess mean differences of continuous and categorical variables between the African Dance and control group. Linear regression was also used to further assess the relationship between PFS scores and group assignment. Pearson correlation was used to assess the relationship between continuous variables. Only 36 participants who were randomized and completed both pre- and post-assessment questionnaires were included in the analysis. Data were analyzed using Stata version 15.1. All tests were conducted at the significance level of 0.05.

4. Results

All of the continuous variables in the data set presented in Table 1 and 2 were normally distributed. The mean age of the dance group was 66.1±4.36 and 67.3±4.98 for culture (table 1). Based on the baseline BMI, both groups started the intervention in the obese category (33.0 ± 4.36 for dance group; 30.7± 4.80 for culture group). Both groups showed low level of fitness with a peak VO2 of 16.6±5.17 for dance and 16.0±4.43 for culture. The mean physical fatigability level was slightly higher in the dance group (16.1±10.3) compared to culture (13.0±8.63) but the differences were not statistically significant, ($p=0.34$). The prevalence of perceived physical fatigability in this population is 50%. Mean follow up time, months between baseline and post sessions was similar between the groups, dance (8.09±2.24) and culture (8.07±2.04). There were no group differences observed in Table 1. When groups were separated by higher and lower perceived physical fatigability (table 2), all baseline variables were similar except for sex ($p=0.035$), history of fatigue ($p=0.016$), limitations related to ability to walk more than a mile ($p=0.003$), and pain interference with activities ($p=0.027$).

Further examination of univariate relations between PFS Physical scores and potential correlates can be found in table 3. Time up and go ($r=0.39$, $p=0.029$), peak VO2($r=-0.34$, $p=0.04$), CES-D 7 ($r=0.42$, $p=0.0002$), pain interference ($r=0.42$, $p=0.0002$), and BMI (0.38, $p=0.003$) were moderately associated with PFS. Limitations associated with the ability to walk more than a mile had the strongest correlation with PFS ($r=0.42$, $p=0.0002$). Peak VO2 (-0.34, $p=0.04$) and limitations associated with the ability to walk more than a mile ($r=-0.54$, $p=0.0001$) were negatively correlated with PFS. The association between BMI and senior physical fitness/function tests (time up and go, step test and arm curls) was moderate or higher. Peak VO2 was moderately associated with attendance (-0.41, $p=0.01$), two minutes step test ($r=0.36$, $p=0.03$), age ($r=-0.32$, $p=0.06$), and arm curl ($r=0.37$, $p=0.03$). The strongest correlation was with BMI ($r=-0.51$, $p=0.002$). The correlation between PFS physical score and attendance, two minutes step test, age, availability of energy and arm curls was minimal (Table 3).

After the evaluation of PFS score differences by intervention group without any adjustments, the results showed that physical fatigability increased in both groups as shown in figure 2. The difference in the post intervention changes ($\Delta \pm SE$) between two groups was not statistically different from zero at the significance level of 0.05 using t-tests ($p=0.57$) as depicted in figure 2. The mean PFS change in the dance group was (2.95 ± 1.36) compared to culture (4.43 ± 1.83). Post intervention scores were also evaluated using several traditional fatigue measure questions. Changes from the CES-D fatigue questions "I could not get going and "everything I did was an effort" also reflected the same trend as the PFS. Fatigue level increased in both groups as shown in figure 3 and 4. One question related to energy extracted from SF-36 was also used to evaluate post-intervention differences and the difference in the change was not statistically different from zero ($p = 0.076$). The culture group had increased level of energy when compared to the dance group whose energy level decreased as seen in figure 5.

A regression model was constructed with total PFS score as a dependent variable and group assignment as a predictor variable adjusting for the effect of age, sex and peak VO2. The regression coefficient for the intervention was not statistically significantly different from zero ($t=-1.07$, $p = 0.29$) and none of the predictors were important. Another regression was performed and only included participants who attended at least 50% of the sessions, with similar findings with mean change in the dance group of (0.79 ± 1.36, $p=0.49$) and culture (3.02 ± 2.12, $p=0.38$). Adjustment for age, peak VO2 and sex did not make any difference. Figure 8 shows that the dance group had a small increase in peak VO2 (0.26 ± 0.65) after 6 months while the culture group's peak VO2 declined (1.25 ± 0.59). However, the results were not statistically significant ($p=0.27$).

In order to understand the relationship between PFS scores and fitness, baseline peak VO2 was divide into two indicator variables where less than 18 indicated low fitness level and more or equal to 18 indicated a higher fitness level in this group (Fleg et al. 2005; Keteyian et al. 2016). About 72 percent of the participants fell in peak VO2 category 1, and their mean PFS score was 16.6 ± 9.43 compared to 9.6 ± 8.37 for those with higher fitness ($p=0.049$).

Lastly, we also performed sensitivity analysis by only looking at people who started the intervention with higher perceived fatigability (PFS >=15 (N=18)). Those in the dance group (-0.58 ± 1.42) showed a small decline when compared to the culture group (5.83 ± 4.31) who had a meaningful increase. The difference in the change was not statistically different from zero ($p=0.09$). There is a trend in that those who started the intervention with high fatigability were benefiting more from the intervention.

5. Discussion

Contrary to our stated hypothesis, we did not find a significant decline in PFS or traditional fatigue measures after the 6 months African Dance intervention. In fact, both the PFS and traditional fatigue measures showed a non-significant increase in fatigue post intervention in both groups. When the results were further evaluated by including only those who attended at least 50 percent of the sessions, mean increase in PFS Physical scores for the dance group was smaller compared to culture group. Adjusting for peak VO2, sex and age did not change the association. Although the results were not statistically significant ($p=0.27$), the dance group had a small increase in peak VO2 (0.26 ± 0.65) after 6 months while the culture group's peak VO2 declined (-1.25 ± 0.59). Even though the slight improvement in fitness hasn't resulted in a reduction in perceived fatigability, this is promising results for the dance intervention. The lack of change in their perceived physical fatigability might be because their exercise tolerance hasn't changed yet.

At baseline, 84% of the participants in the dance class indicated that they had no history of fatigue but, in fact, the prevalence of greater perceived physical fatigability in this population was 50%. The traditional fatigue measures were not able to capture greater perceived physical fatigability detected using the PFS. The prevalence of fatigue when using the traditional fatigue questions from CES-D was low and similar between the two groups. Each CES-D question had an overall mean score of less than one out of three, "I felt that everything I did was an effort'' 0.31 ± 0.62 and "I could not get going" 0.47 ± 0.77. Those with higher perceived physical fatigability were more likely to be women than men, which is comparable to findings in other studies (LaSorda et al. 2018). Lasorda et al (LaSorda et al. 2018) reported the prevalence of greater perceived fatigability of 28% for those 60 – 69 years old from the Long Life Family Study, a population of predominantly whites, which is considerably lower than our study. This is not surprising as the burden of fatigue is much higher in this population of African descent compared to other races. Song et al (Song et al. 2002) had similar finding in a study examining a relationship between age, gender and fatigue in multicultural and socioeconomically diverse community-based urban sample. Age and gender were found to be important predictors of fatigue among African Americans. It was also suggested that high level of stress experienced by AA daily may causes changes in preventative health behaviors and illness coping mechanisms that may result in negative health effect long term. Low SES is a known contributor of health disparities and may contribute to high fatigue levels in AA Differences may also be explained by several factors including poorer health status, barriers to adequate health care and environmental exposures (Bardwell et al. 2006; Song et al. 2002). In this study, AA women also had higher level of fatigue compared to African American men. This could be as a result of women having multiple roles at home while also experiencing work related stress (Rose et al. 2017).

PFS was correlated with measures of physical function and fitness. PFS had a moderate inverse relationship with peak VO2 (r=-0.34) while the relationship with BMI was positive (r=0.38). Greater fatigability was correlated with lower peak VO2, a measure of aerobic fitness. Higher BMI is correlated with lower perceived physical fatigability. These finding are consistent with the current literature (Cooper et al. 2019)

Although it was counter to our hypothesis, an increase in perceived physical fatigability post intervention could be explained by several factors. At baseline, 50% of the participants had higher level of perceived physical fatigability and 72%of the participants had a VO2 peak of less than 18 ml/kg/min. Not only were these participants fatigued, their aerobic fitness was very low. Age was negatively associated with peak VO2 (r=-0.32). A decline in peak VO2 with age is strongly associated with functional independence and quality of life. As older adults age, changes in body composition resulting from aging leads to difficulty in maintaining independent living and a reduction in aerobic functional capacity (Fleg et al. 2005). Alexander et al (Alexander et al. 2010) explored the idea of fatigue being defined as a disorder associated with energy balance. In a healthy individual, 60 – 70 percent of the energy is used for maintaining life at rest. One's resting metabolic rate (RMR) declines with age requiring even more energy to sustain bodily functions at rest. With aging, a lot of physiological changes and age associated disease may make older adults to require more energy at rest to sustain bodily functions. The amount of energy required for RMR increases significantly with aging leading to remaining low energy needed to perform physical and cognitive activities. It is possible that since these individuals have high level of perceived physical fatigability and are unfit, they are operating at their maximum energy level and therefore reporting high levels of perceived physical fatigability. Even though 84% of the dance participants reported having no fatigue, the PFS, a more sensitive measure reported greater perceived physical fatigability of 50% (Schrack, et al JGMS, Simonsick 2018 JAGS). It is also possible that during the dance sessions, due to these participants being unfit and operating at their highest energy threshold, they intentionally reduce their performance to a comfortable level in older to preserve energy. As they were forced to exercise at the moderate intensity for 6 months, that might have exhausted their energy reserve thus making them more fatigued. This could explain the reason for participants reporting no history of fatigue while reporting greater fatigability at the same time. This highlights the importance of using a more sensitive fatigue measures that anchors perceived exertion to activities taking into account the intensity and duration of that particular activity.

Furthermore, the intervention requires participants in the dance class to exercise at moderate intensity physical activity level (60 – 75% of their heart rate reserve). About 72 percent of the participants had a peak VO2 of less than 18 ml/kg/min and their mean perceived physical fatigability score was 16.6. The overall mean BMI was in the obese category. Most of these individuals were unfit, obese and had to undergo deconditioning from physical inactivity. This process would require a lot of energy and force participants to work at their highest energy threshold contributing to increased perceived physical fatigability post intervention. Deconditioning from sedentary lifestyle may contribute to unexplained fatigue syndrome. It is possible that moderate intensity exercise may be too intense initially to improve symptoms of low energy among individuals who are sedentary (Puetz et al. 2008). Long term improvement in aerobic capacity and physical function could help improve perceived physical fatigability and feelings of energy. As these participants continue to increase their level of fitness and general physical function, they may begin to experience low level of fatigue once their bodies fully adjust to physiological changes. BMI was positively correlated with PFS scores ($r=0.38$) and this is consistent with current literature (Cooper et al. 2019). Cooper et al (Cooper et al. 2019) demonstrated that BMI was associated with PFS scores in old age. Reducing the burden of perceived fatigability may also require researchers to look more into factors that are strongly correlated with PFS such as BMI, measures of physical function and cardiorespiratory fitness. African dance has shown promising signs in reducing weight in a small randomized controlled trial in an AA population. In this trial, the dance group had a reduction in weight ($t(12)=2.38, p=0.03$) compared to the cultural education group ($t(10)=-2.22$, $p=0.05$), (Stillman et al. 2018).

Glynn et al (Glynn et al. 2020) evaluated the impact of baseline fatigue on the effectiveness of a PA intervention to prevent major mobility disability and persistent major mobility disability in participants from the LIFE study. It was concluded that a long-term moderate intensity intervention was effective at maintaining physical function in older adults whose baseline fatigue was higher. This finding might further strengthen our claim that our intervention was more beneficial among those who started with a higher baseline fatigue as it is known in literature that fatigue is strongly associated with measures of physical function (Vestergaard et al. 2009; Glynn et al. 2020) . Although it is a trend and the sample size is small, there is an indication that the dance group's perceived fatigability didn't get worse. Fatigability was slightly reduced in the dance group but increased in the culture group. Results from the sensitivity analysis when only looking at those who had higher fatigue at baseline might suggest that the exercise might have helped temper the COVID stress for those who were in the dance group. This potentially indicates that the intervention might have helped those who were in the dance group cope better with COVID stress compared to those in culture. The intervention was more effective among those who began the intervention with higher fatigue.

Implications of COVID-19 on the trial

The finding of this pilot work needs to be tempered because of the highly likely impact of the COVID-19 pandemic on the trial. About 81% of the data was collected during the pandemic. The stay-at-home orders might have interfered with the participants' perception of fatigue or their fatigue level. The baseline data were collected prior to the pandemic and clearly show in this age group of AA that the burden of fatigue is higher than what we see in a comparable, primarily white population. This indicates that this is a major public health concern and being able to identify a culturally sensitive intervention is of major public health importance. REACT is ongoing and we will have the ability to look at differences pre and post COVID later on.

Strength and limitations

A small sample size reduced our power to be able to detect small group differences post intervention. It is possible that the participants did not have enough time in the intervention to start reaping the benefits of moderate intensity physical activity in reducing feelings of low energy. The strength of the study is that this is preliminary results, more incoming data will enable us to fully determine the effects of a 6 months African dance intervention on perceived physical fatigability.

This is also a novel intervention which adds to currently epidemiological literature in this underserved community.

Future Direction

We have accompanying data of mental PFS that will be analyzed and will give insightful information on the changes in perception of fatigue and whether it varies by intervention group. We will be able to examine if there was a differential effect on mental and physical fatigue between the two groups. One may hypothesize that those who are in the culture group may exhibit improvement in mental fatigue due to their engagement in mentally stimulating activities. Furthermore, the inclusion of cognitive function variables will enable us to determine the impact of the intervention on perception of fatigue and whether physical or mental fatigability serve as a mediator between physical activity and cognition.

Although it was beyond the scope of the study because the primary outcome of this trial has not been evaluated, we could do a secondary analysis later on to examine the relationship between fatigue and cognitive function. Mental fatigue is indicative of motivation and reward, and we will carefully examine the role of cognitive function on fatigue.

Conclusion

The preliminary results from this pilot study do not provide a strong evidence of the effectiveness of the 6-month African dance intervention in modifying perceived physical fatigability. Increased sample size from the full REACT cohort will be important to evaluate to see whether a dance intervention reduces perceived physical fatigability in older adults as we know that it is an important mediator in the relationship between physical activity and function (Qiao et al. 2020). By identifying an enjoyable, culturally relevant intervention for older underserved adults, we can intervene along the disablement pathway.

Appendix: Tables and figures

Table 1: Baseline characteristics by intervention groups (N=36)

	Total (n=36)	Dance (n=19)	Culture (n=17)	p value
Demographics				
Age, years	66.7±4.6	66.1±4.36	67.3±4.98	0.47
Years of education, years	15.3±2.5	14.9±2.63	15.8±2.31	0.32
Sex, female	29 (81)	15 (79)	14 (82)	0.80
Lifestyle and Anthropometric				
Body Mass Index, kg/m^2	31.9±6.2	33.0±7.24	30.7±4.80	0.27
Non-smokers	30 (83)	16 (84)	14 (82)	0.88
Physical Function/Fitness				
Does your health limit your ability to walk more than a mile (range 1 – 3)*	2.36±0.76	2.16±0.76	2.59±0.71	0.090
Two minutes step test, count	66.2±17.2	65.3±18.8	67.2±15.9	0.75
Average time up and go, seconds	7.13±1.58	7.34±1.73	6.90±1.41	0.41
Arm-curls, count	13.1±2.98	12.8±2.48	13.4±3.52	0.61
Peak VO2, mL/kg/min	16.3±4.78	16.6±5.17	16.0±4.43	0.71
Fatigue and Fatigability				
Do you have a lot of energy? (range 1 – 6)**	3.25±1.52	2.95±1.35	3.59±1.66	0.21
PFS physical score (range 0-50)[c]	14.6±9.6	16.1±10.3	13.0±8.63	0.34
Percent of greater perceived fatigability (PFS>=15)	18(50)	12(63)	6(35)	0.091
I felt that everything I did was an effort (range 0 – 3)[a]	0.31±0.62	0.37±0.76	0.24±0.44	0.53
I could not get going (range 0-3)[a]	0.47±0.77	0.47±0.84	0.47±0.72	0.99
History of fatigue (No fatigue)	31(86)	16(84)	15(88)	0.73

Other				
How much does pain Interference with your normal activities? (range 1 – 5)***	1.75±0.84	1.84±0.96	1.65±0.70	0.50
Follow-up time, months	8.08±2.12	8.09±2.24	8.07±2.04	0.98

Mean±SD or [N] %

a= Questions from Center for Epidemiological Studies Depression Scale (CES-D)

0 = rarely or none of the time, 1 = some or a little of the time), 2 = occasionally or a moderate of time and 3 = most of the time

Questions from 36-Item Short Form Survey (SF-36)

*Scale: 1 = yes, limited a lot, 2 = yes, limited a little, 3 = no, not limited

**Scale: 1 = all the time, 2 = most of the time, 3 = a good bit of the time, 4 = some of the time, 5 = a little of the time, 6 None of the time

***Scale: 1 = not at all, 2 = A little bit, 3 = Moderately, 4 = quite a bit, 5 = Extremely

c = Pittsburgh Fatigability Scale (PFS)

Table 2: Baseline characteristics by PFS Category (N=36).

	Total (n=36)	Low Physical Fatigability (n=18)	High Physical Fatigability (n=18)	p value
Demographics				
Age, years	66.7±4.6	66.2±4.22	67.2.8±5.04	0.54
Years of education, years	15.3±2.5	15.3±2.05	15.3±2.91	0.97
Sex, female	29 (81)	12 (67)	17 (94)	0.035
Lifestyle and Anthropometric				
Body Mass Index, kg/m^2	31.9±6.2	30.1±3.65	33.8±7.70	0.07
Non-smokers	30 (83)	14 (77)	16 (89)	0.37
Physical Function/Fitness				
Does your health limit your ability to walk more than a mile (range 1 – 3)*	2.36±0.76	2.72±0.57	2.00±0.77	0.003
Two minutes step test, count	66.2±17.2	66.7±17.7	65.7±17.3	0.87
Average time up and go, seconds	7.13±1.58	6.74±1.34	7.52±1.74	0.13
Arm-curls, count	13.1±2.98	13.3±2.25	12.8±3.62	0.62
Peak VO2, mL/kg/min	16.3±4.78	17.8±5.72	14.9±3.14	0.71
Fatigue and Fatigability				
Do you have a lot of energy? (range 1 – 6)**	3.25±1.52	3.11±1.60	3.39±1.46	0.55
I felt that everything I did was an effort (range 0 – 3)[a]	0.31±0.62	0.11±0.32	0.50±0.79	0.53
I could not get going (range 0-3)[a]	0.47±0.77	0.33±0.59	0.61±0.92	0.99
History of fatigue (No fatigue)	31(86)	18(100)	13(72)	0.016
Other				
How much does pain Interference with your normal activities? (range 1 – 5)***	1.75±0.84	1.44±0.62	2.06±0.94	0.027

Follow-up time, months	8.08±2.12	7.98±1.88	8.18±2.38	0.78

Mean±SD or [N] %

a= Questions from Center for Epidemiological Studies Depression Scale (CES-D)

0 = rarely or none of the time, 1 = some or a little of the time), 2 = occasionally or a moderate of time and 3 = most of the time

Questions from 36-Item Short Form Survey (SF-36)

*Scale: 1 = yes, limited a lot, 2 = yes, limited a little, 3 = no, not limited

**Scale: 1 = all the time, 2 = most of the time, 3 = a good bit of the time, 4 = some of the time, 5 = a little of the time, 6 None of the time

***Scale: 1 = not at all, 2 = A little bit, 3 = Moderately, 4 = quite a bit, 5 = Extremely

c = Pittsburgh Fatigability Scale (PFS)

Table 3: Correlation between continuous variables.

	1	2	3	4	5	6	7	8	9	10	11	12	13
1. PFS Physical score													
2. Time up and go	0.39[c]												
3. Peak VO2	-0.34[a]	-0.33[a]											
4. Attendance	0.21	0.13	-0.41[b]										
5. Two minutes steps	-0.03	-0.61[d]	0.36[a]	-0.13									
6. Age	-0.09	0.45[c]	-0.32	0.25	-0.28[a]								
7. Body Mass Index	0.38[b]	0.58[d]	-0.51[b]	0.39[a]	-0.52[d]	0.25							
8. CES-D 7	0.42[c]	0.24	0.01	0.14	-0.1	-0.13	0.22						
9. CES-D 20	0.28[c]	0.14	-0.16	0.28	-0.20	-0.24	0.26	0.63[d]					
10. SF-36 Energy	0.19	0.08	0.17	-0.11	-0.11	-0.15	0.07	0.45[d]	0.44[c]				
11. SF-36 Mile walk	-0.54[d]	-0.45[c]	0.24	-0.03	0.26	-0.19	-0.56[d]	-0.17	-0.08	-0.43[c]			
12. Arm curls	-0.05	-0.42[c]	0.37[b]	-0.18	0.50[d]	-0.25	-0.35[c]	-0.18	-0.28	0.08	0.13		
13. SF-36 Pain Interference	0.42[c]	0.16	-0.24	0.17	-0.23	-0.22	0.30	0.33[b]	0.44[d]	0.35[d]	-0.41[c]	-0.23	

$p < 0.05$ = a

$p < 0.01$ = b

$p < 0.001$ = c

$p < 0.0001$ = d

Questions from Center for Epidemiological Studies Depression Scale (CES-D)

CES-D 7 = I felt that everything I did was an effort

CES-D 20 = I felt that everything I did was an effort

Questions from 36-Item Short Form Survey (SF-36)

SF-36 Energy = Do you have a lot of energy

SF-36 Mile walk = Does your health limit your ability to walk more than a mile

SF-36 Pain Interference = How much does pain Interference with your normal activities?

Pittsburgh Fatigability Scale (PFS)

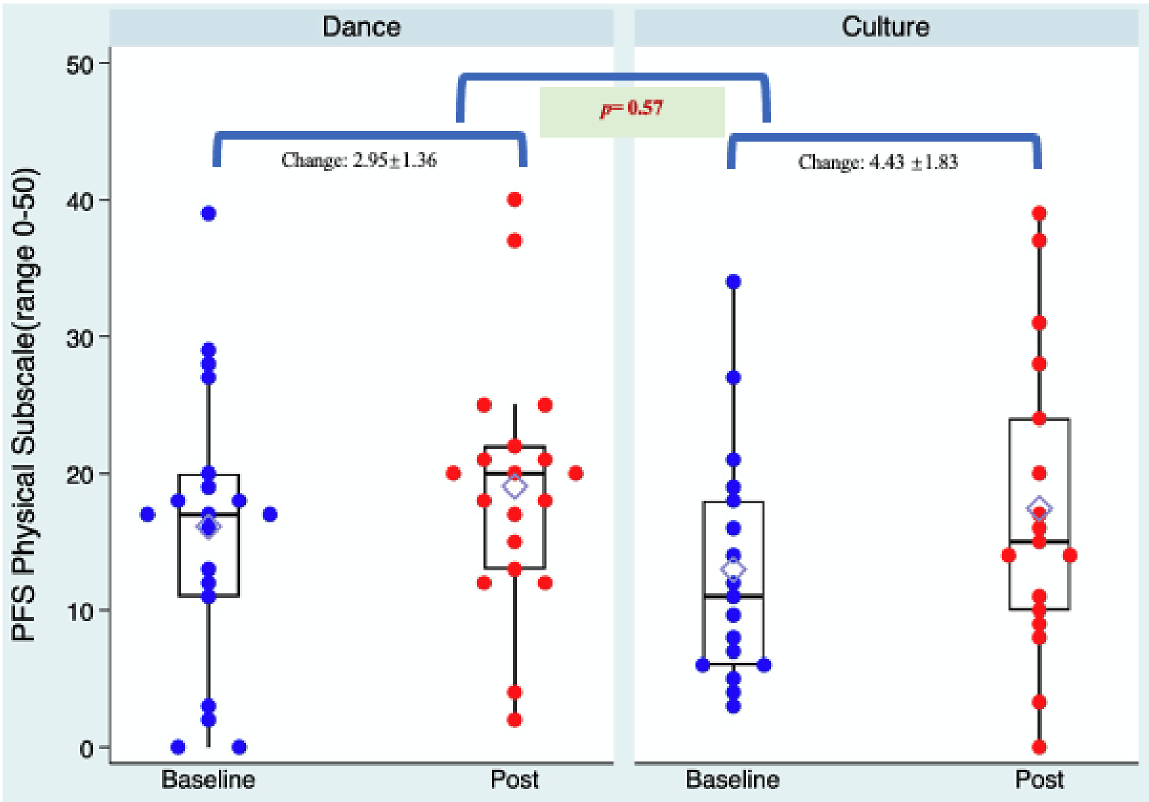

Figure 2: The pre and post distributions of PFS Physical scores by intervention groups. This displays changes (mean Δ ± SE) in the Pittsburgh Fatigability Scale (PFS) scores.

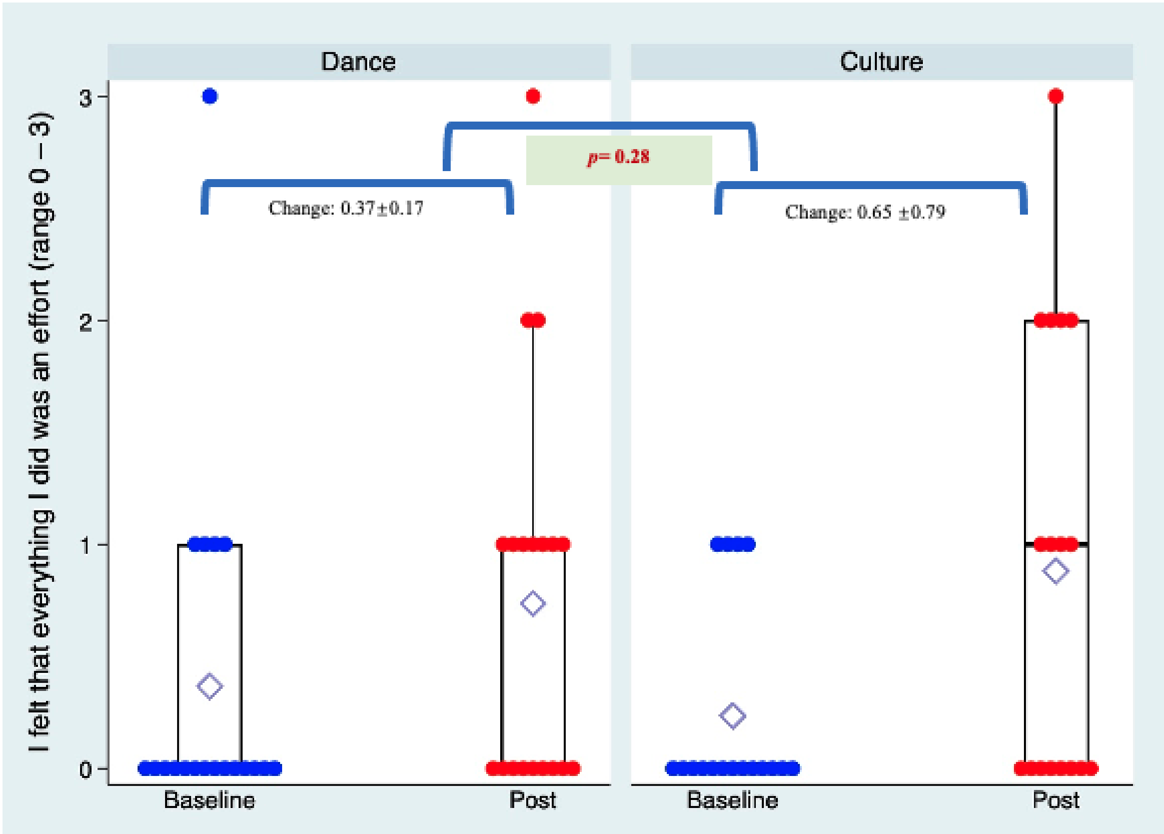

Figure 3: The pre and post distributions of the CES-D question "I felt that everything I did was an effort" by intervention groups. This displays changes (mean $\Delta \pm$ SE) in fatigue measured by a single question from CES-D.

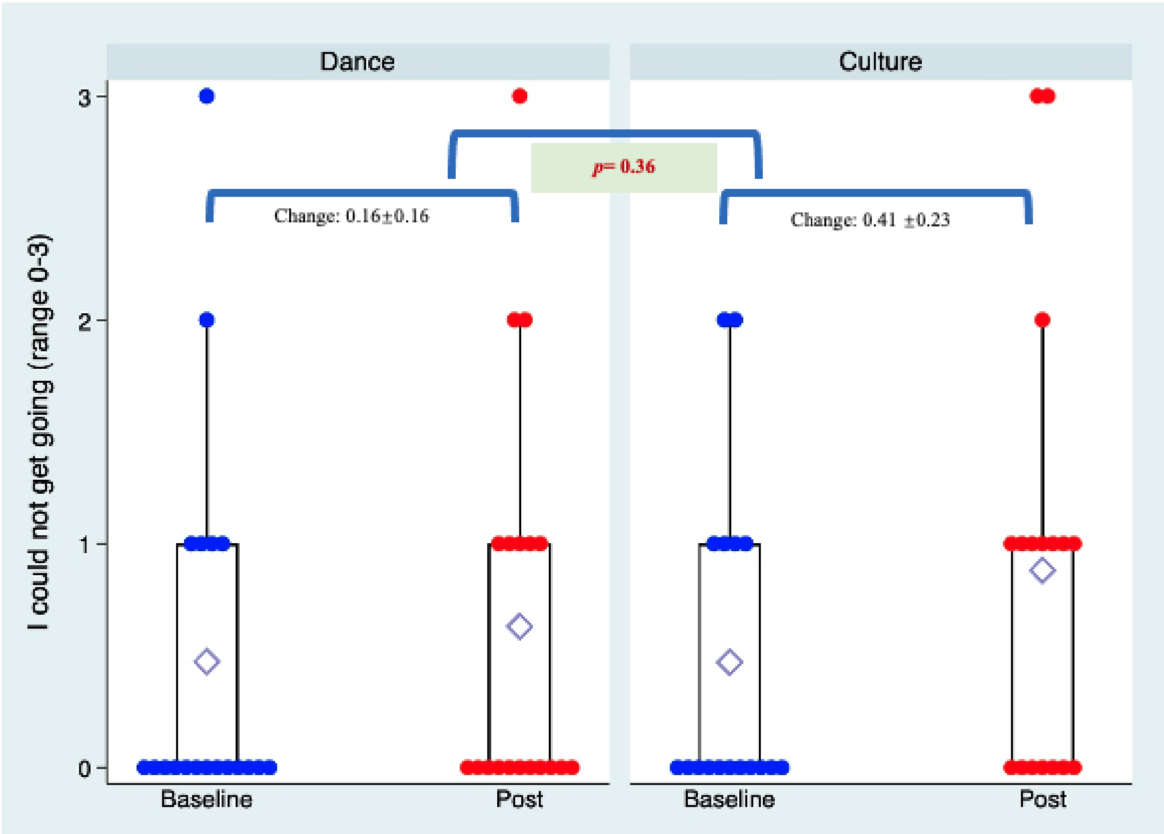

Figure 4: The pre and post distributions of the CES-D question "I could not get going" by intervention groups. This displays changes (mean Δ ± SE) in fatigue measured by a single question from CES-D.

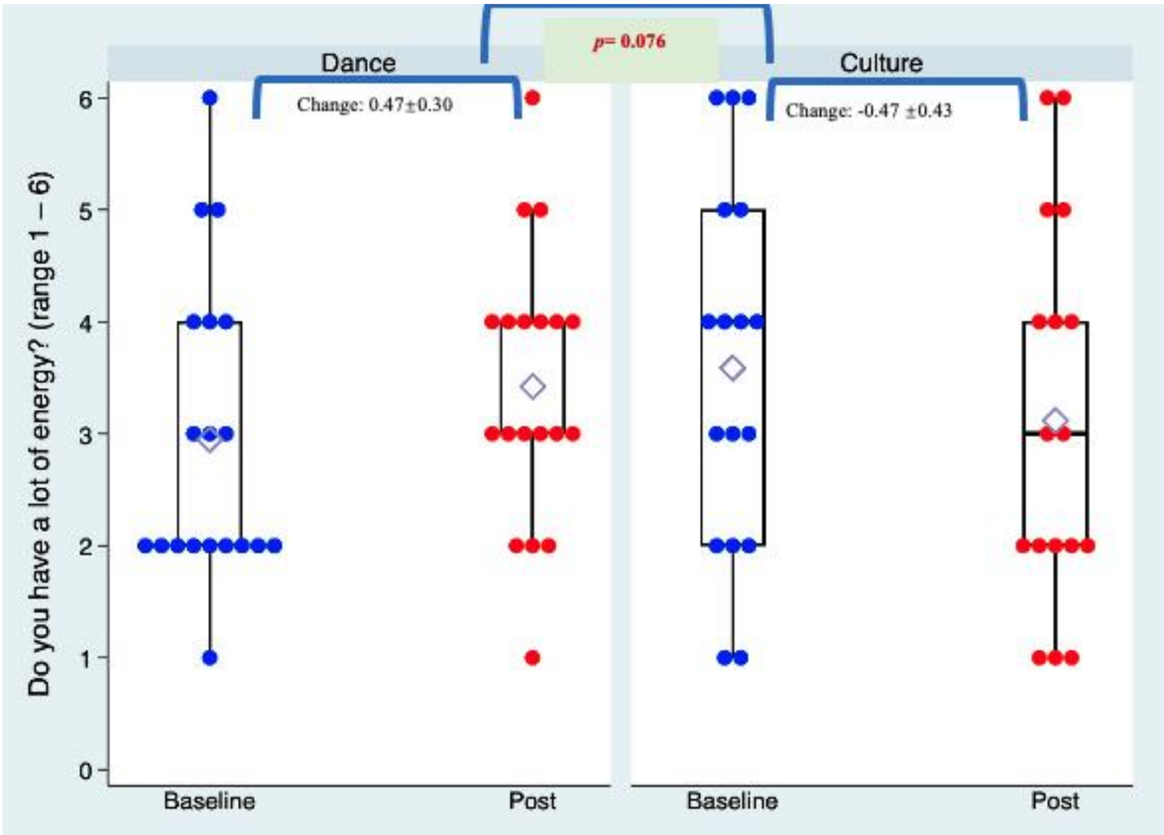

Figure 5: The pre and post distributions of SF-36 question " Do you have a lot of energy" by intervention groups. This displays changes (mean Δ ± SE) in energy measured by a single question from SF-36.

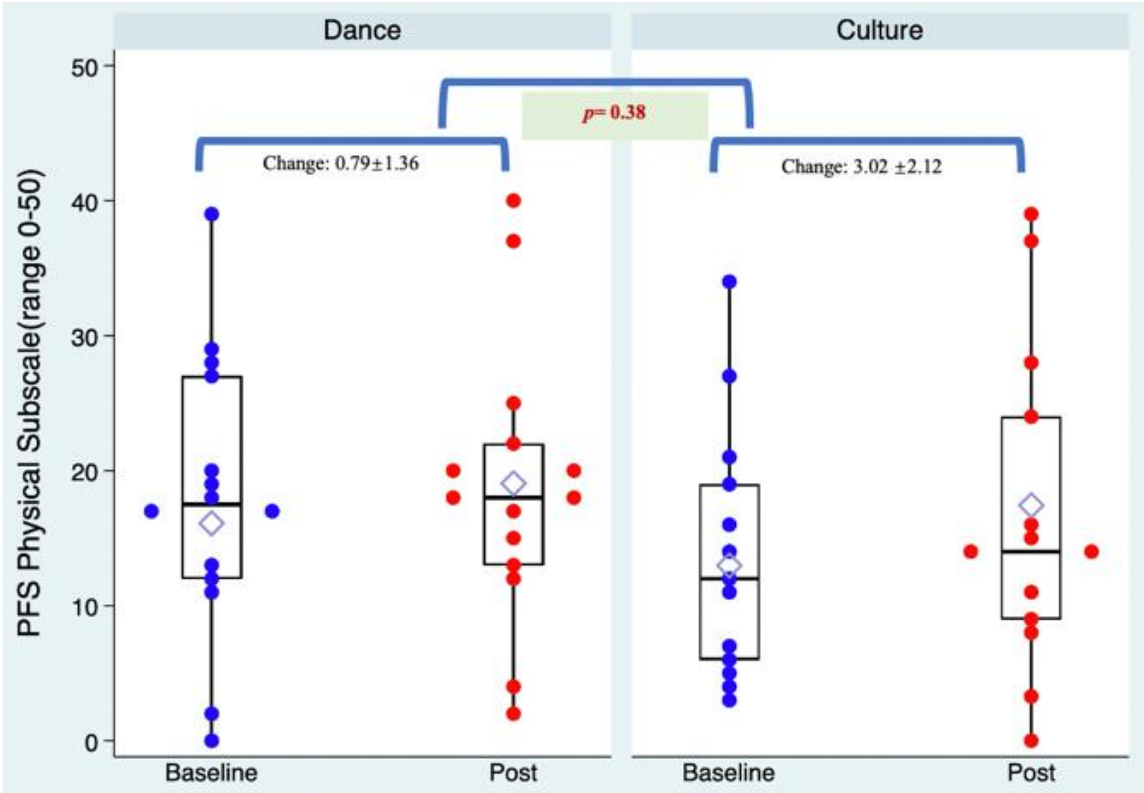

Figure 6: The pre and post distributions of PFS Physical scores by intervention groups for those who attended at least 50% of the sessions. This displays changes (mean Δ ± SE) in the Pittsburgh Fatigability Scale (PFS) scores.

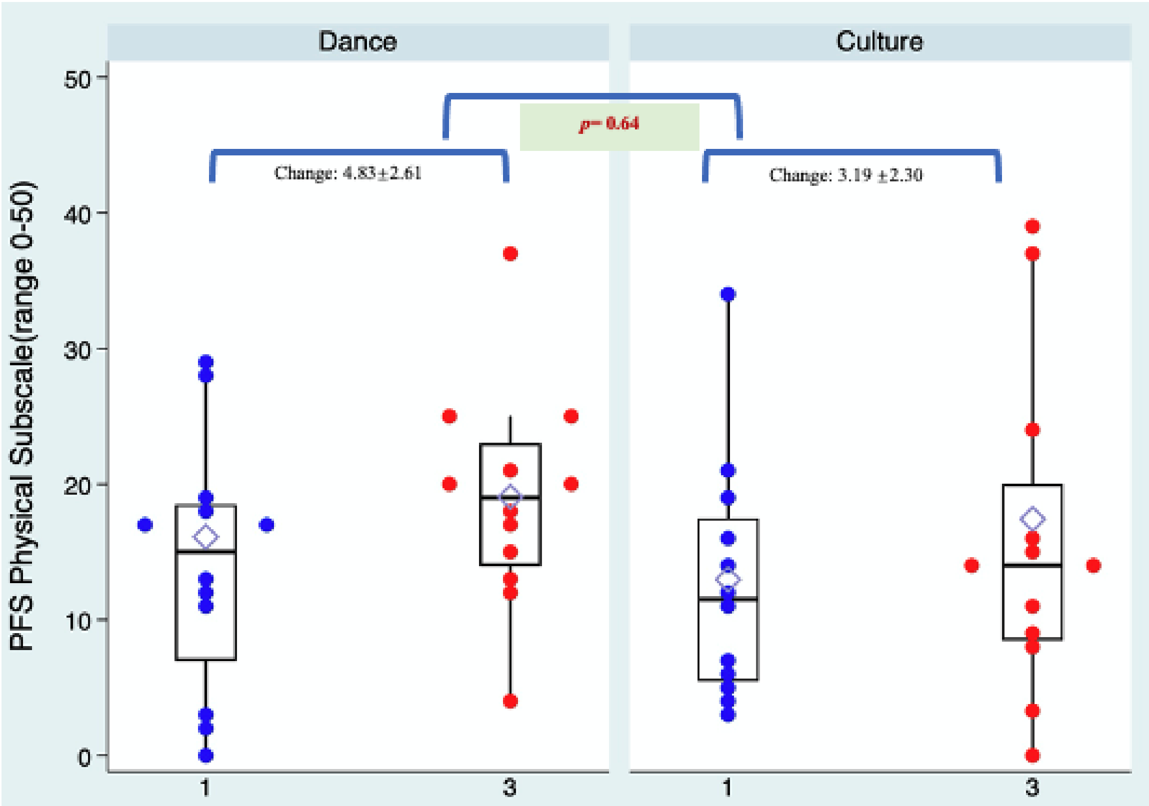

Figure 7: The pre and post distributions of PFS Physical scores by intervention groups for those who completed both pre and post submax VO2. This displays changes (mean Δ ± SE) in the Pittsburgh Fatigability Scale (PFS) scores.

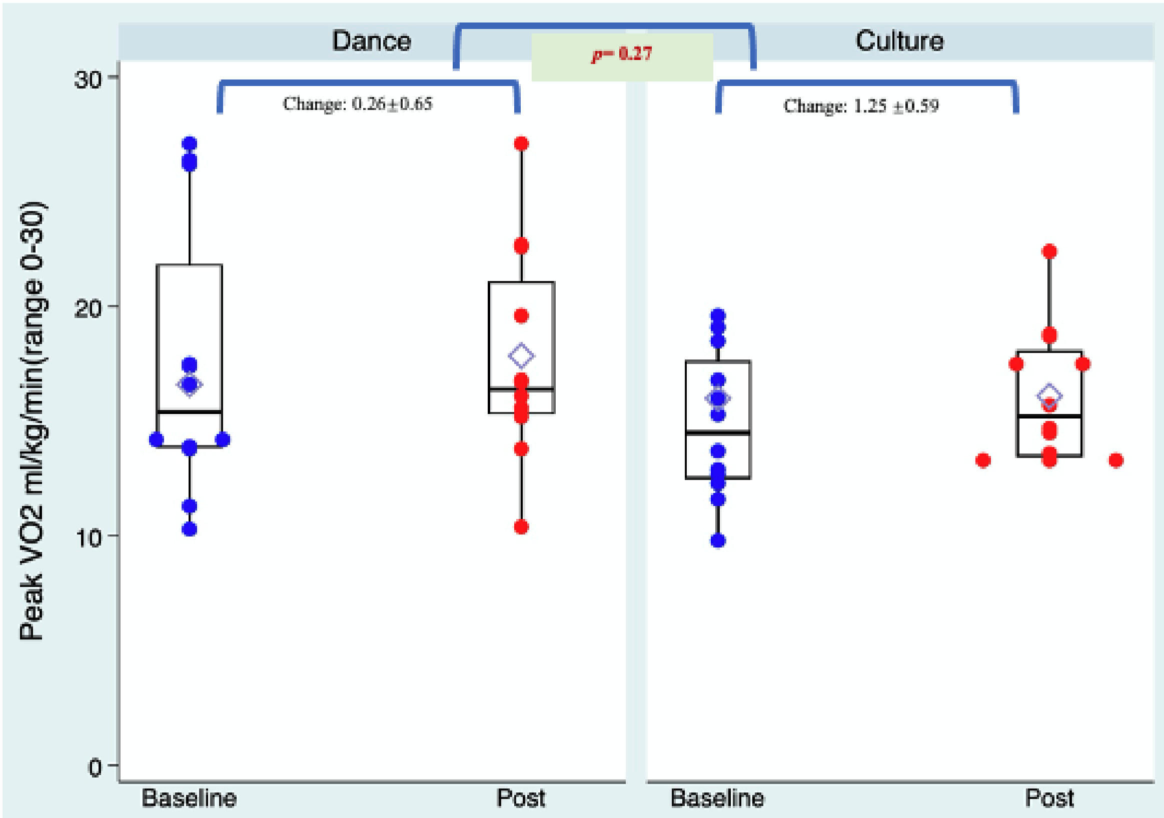

Figure 8: The pre and post distributions of peak VO2 scores by intervention groups for those who completed both pre and post submax VO2. This displays changes (mean Δ ± SE) in peak VO2 scores.

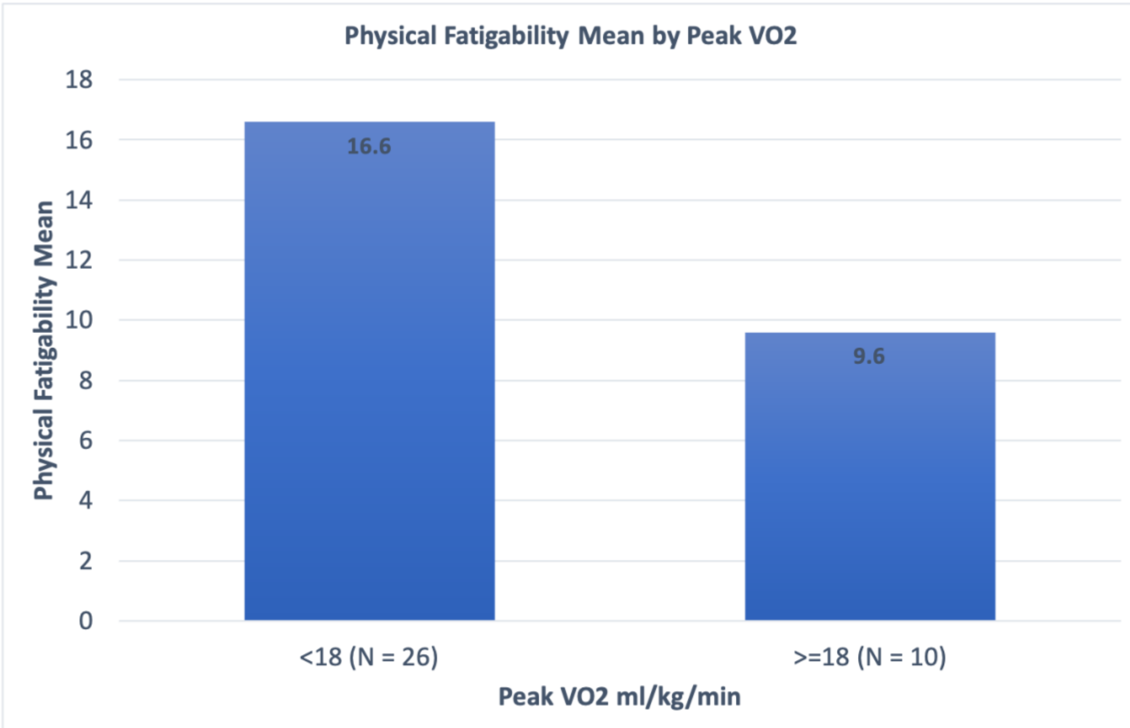

Figure 9: Baseline Physical Fatigability Mean scores by Peak VO2 levels.

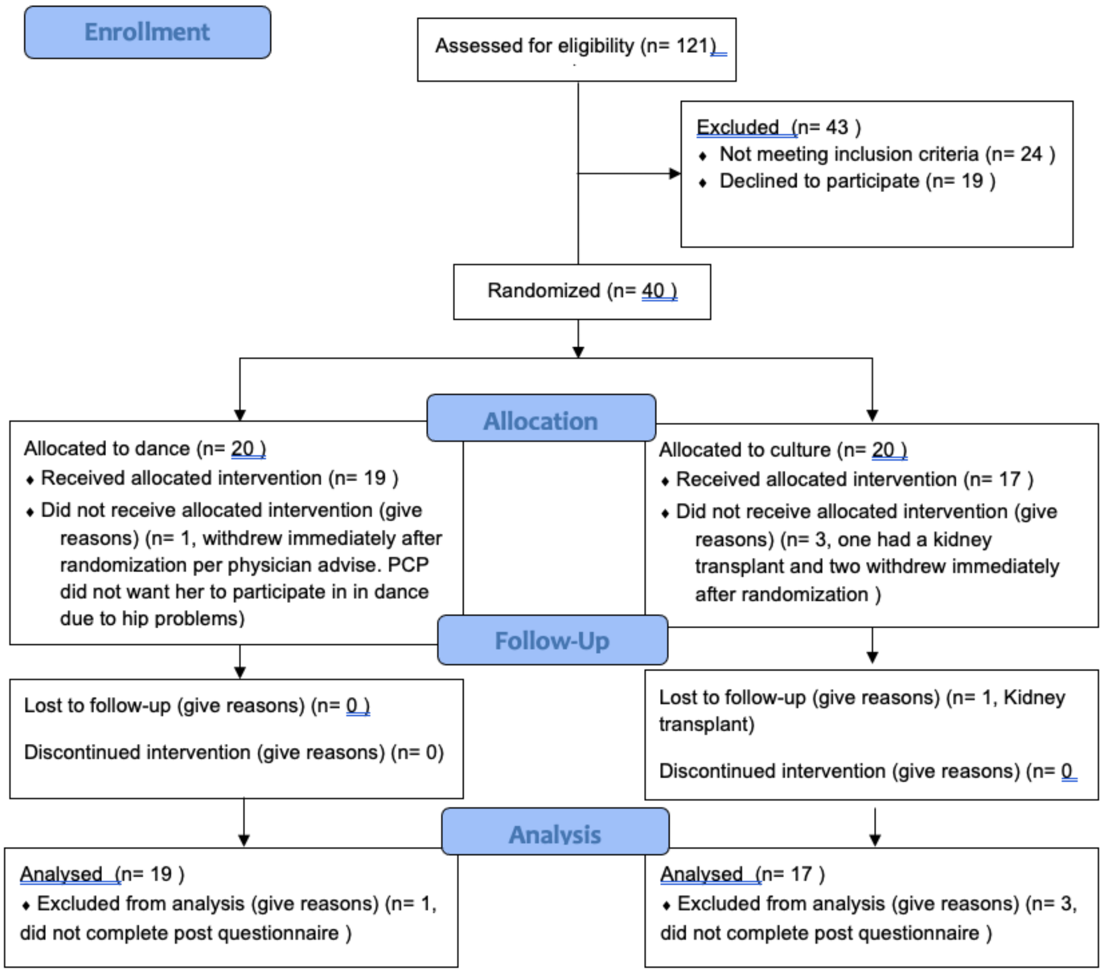

Figure 10: Flow diagram of REACT study enrollment.

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