The Effects of Low-Tempo and High-Tempo Zumba® in Individuals with Developmental Disabilities

by

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Abstract

Adults with developmental disabilities (DD) exhibit deficits in aerobic capacity, functional mobility, balance, healthy body composition, and executive functioning across development. Different exercise interventions have been shown to improve different outcome measures in this population. However, few studies have examined the impact of adapted exercise interventions from a more comprehensive perspective (i.e., physical and cognitive health). The present study examined the effects of a 10-week (2 session/week, 1 hour/session) adapted Zumba® dance intervention on aerobic capacity, functional mobility, balance, body composition, and executive functioning in 44 adults with DD ages 20.8–69.2 years. In addition to examining the overall differences between control and intervention conditions, differences in conditions were also examined. To this end, the present study employed a cross-over design with a 3-month wash-out period in which participants in the intervention also served as controls. The participants were quasi-randomized (to match the level of daily function across conditions) into one of two Zumba intervention conditions: low tempo Zumba® (0.75 speed; $n = 23$), and high tempo Zumba® (normal speed; $n = 21$). When participants served as controls, they participated in regular daily activities. A significant Condition x Time interaction was observed for the 6-Minute Walk Test and Timed-Up-And-Go; participants in the low and high tempo Zumba® conditions significantly increased the distance walked for the 6-Minute Walk Test and reduced the total time to complete the Timed-Up-And-Go. The control condition did not improve for either task. There were no significant Condition x Time interactions for the Clinical Test of Sensory Interaction in Balance, Percent Body Fat, or Flanker Task. Taken together, these results suggest that 10-weeks of adapted Zumba® improves functional mobility and aerobic capacity, but not balance, body composition, and executive function in adults with DD. Moreover, adapted

Zumba® with a slower tempo may enable a broader range of adults with DD to participate and benefit from this type of program commonly offered in the community.

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List of Abbreviations

ADL	Activities of Daily Living
ASD	Autism Spectrum Disorder
CP	Cerebral Palsy
DD	Developmental Disability/Disabilities
DS	Down Syndrome
EF	Executive Function
ID	Intellectual Disability/Disabilities
LMER	Linear Mixed Effects Regression
MVPA	Moderate-to-Vigorous Physical Activity
PA	Physical Activity
TUG	Timed-Up-and-Go
6MWT	6-Minute Walk Test

Chapter 1 – Introduction

Overview, Prevalence, and Significance

The term developmental disability (DD) encompasses a group of long-term disabilities that begin before the age of 18 years and include autism spectrum disorder (ASD), cerebral palsy (CP), Down syndrome (DS), intellectual disabilities (ID), and other disabilities. Nearly 17% of children in the United States(US) are diagnosed with a DD. Furthermore, the prevalence of DD has increased from 2009 to 2017; ID and DS diagnoses increased by more than 25% (from 0.93% to 1.21%), and ASD has doubled (from 1.12% to 2.49%) over this period (Zablotsky et al., 2019). Simultaneously, the life expectancy of those with DS has also increased into the sixties and for those with ID into their seventies, creating a growing population of older adults with DD (Coppus, 2013). However, despite the increase in life expectancy, individuals with DS and ID do not live as long as typically developing individuals (Coppus, 2013) and have a lower quality of life throughout their lifespan (Blaskowitz et al., 2020). Therefore, interventions are needed to improve the health and quality of life in adults with DD.

Individuals with DD face disproportionate physical health problems compared to their typically developing peers (de Winter et al., 2015; Rimmer et al., 2010). For example, low cardiorespiratory fitness (Oppewal et al., 2013), low physical activity (PA) levels (Frey et al., 2008; Hilgenkamp et al., 2012), poor functional mobility (Cleaver et al., 2009), and greater obesity (Melville et al., 2009; Segal et al., 2016) are consistently reported. Together, these issues lead to secondary health conditions that contribute to early morbidity and reduced quality of life for the growing population of adults with DD (Rimmer et al., 2007). Moreover, Landes et al., (2020) found that two of the leading causes of death for individuals with DD, heart disease and diabetes, were correlated with low levels of PA Therefore, programs aimed at increasing physical activity (PA) may be associated with improved physical health outcomes and reduction in early morbidity.

Indeed, access to adapted PA and fitness programs may attenuate the risk for health problems, poor quality of life, and early morbidity in this population (Oppewal & Hilgenkamp, 2019)., Older adults (> 50 years old) with ID with high fitness skills (i.e., cardiorespiratory fitness, grip strength, balance) have much higher survival rates over a 5-year period than those with low fitness skills (Oppewal & Hilgenkamp, 2019). Programs aimed at increasing aerobic function and muscle strengthening have been found to improve overall health and well-being in adults (ages 18-75 years) with ID (Bouzas et al., 2019). Thus, there is a clear need to develop and implement adapted PA and fitness programs to promote healthy aging and reduce physical health disparities in this underserved population (Heller & Sorensen, 2013).

Physical Activity and Fitness in Individuals with DD

The PA Guidelines for Americans (2019) recommend that in order to be healthy, one must participate moderate levels of PA. Specifically, adults should complete 150 minutes of moderate PA per week. The recommendation includes a variety of exercises for older adults, including those that improve balance and mobility. Similar recommendations have been made for adults with DD (Physical Activity Guidelines, 2nd Edition, 2019); guidance is provided to specifically address health issues related to low levels of physical activity common in adults with DD.

Adults with DD consistently fail to meet PA guidelines for moderate-to-vigorous PA (MVPA), and step counts (Dixon-Ibarra et al., 2013; Hilgenkamp et al., 2012; Oviedo et al., 2017). Although only 33% of typically developing older adults met the PA recommendations, far fewer older adults with ID (ages 50-77; 6%) and younger adults with ID (ages 20-49; 13%) met the PA recommendation of at least 30 minutes of daily Moderate to Vigorous Physical Activity(MVPA) (Dixon-Ibarra et al., 2013). Similar findings were reported for both older and younger adults with ID (M = 54 years old); only 10.7% of all participants met PA guidelines of 30 minutes of daily MVPA (Oviedo et al., 2017).

When examining recommendations based on step count, only 17% of older adults with ID (ages 50-89) met the recommendations of 10,000 steps a day. Only 39% of older adult participants completed more than 5,000 steps a day (Hilgenkamp et al., 2012). Taken altogether, in addition to being less active than typically developing older adults, older adults with DD exhibit an age-related decrease in PA compared to younger adults with DD. This decline in PA makes them increasingly vulnerable to secondary conditions that may be mitigated by PA participation.

Balance Difficulties and Functional Mobility in Individuals with Developmental Disabilities

Adults with DD exhibit deficits in functional mobility, with these appearing early in adulthood (i.e., in the 30s; Cleaver et al., 2009) and increase with age (Cleaver et al., 2009). Deficits in functional mobility may be due to poor balance, which is also common in adults with DD (Enkelaar et al., 2012). For example, adults with ID and DS (ages 20-39) exhibit larger standing sway amplitude than their typically developing peers (Dellavia et al., 2009). Kokubun et al. (1997) found that both the amplitude and frequency of sway in individuals with ID and DS (ages 10-20 years) were worse than their typically developing peers (Kokubun et al., 1997). Moreover, individuals with ID (ages 21-81) had significantly poorer performance on the Berg Balance Scale(a measure of dynamic and static balance) than their peers (Hale et al., 2007), suggesting broad deficits in sitting, standing, static, and dynamic balance. These deficits in functional mobility and balance place individuals with DD at increased likelihood of falling

(Enkelaar et al., 2012). Moreover, these issues may contribute to lower levels of PA in this population, for example, balance deficits reduce the ability to engage in some physical activities, and fear of falling may reduce the desire to participate in PA (Enkelaar et al., 2012).

Executive Functioning and Exercise or Physical Activity

Executive function (EF) is necessary to plan purposeful, goal-directed action and monitor movement outcomes. Moreover, EF is critical to the performance of daily living activities, including dressing, bathing, and scheduling activities (Lezak, 1982). Attention, working memory, and response inhibition are components of EF that are impaired in individuals with DD(Lezak, 1982). For example, children with ID perform worse than their typically developing peers in EF tasks (der Molen et al., 2007). Adults with DS exhibit decreased attention compared to peers (Rowe et al., 2006). These deficits in EF exhibited in childhood may carry over and indeed worsen with age.

EF is especially critical for aging individuals with ID, including DS, as this population may be at increased risk for memory loss or dementia (Visser et al., 1997). Indeed, an age-related decline in EF was observed in 84 adults with DS or ID ages 30 and older (Devenny et al., 2000). Similarly, age-related declines in EF were observed in individuals with DS (n = 30), particularly those approaching age 50 (Adams & Oliver, 2010). Given the importance of EF to daily living, attenuating the decline in EF is critical for this population to maintain independence.

Chen et al. (2019) examined the effects of a 15-week (twice a week) adapted soccer program on working memory and selective attention in young adults with and without ID (n = 10). The researchers found no improvement in working memory (Corsi Block Tapping Task) and a trend toward improving selective attention and inhibition (NIH Toolbox Flanker). These limited results may be due to the small number of participants with ID included in the study.

Ringenbach et al. (2014) examined the effects of acute bouts of assisted cycling in individuals (ages 14-25) with DS ($n = 9$); assisted cycling was associated with improved reaction time and cognitive planning, compared to voluntary cycling or no cycling (Ringenbach et al., 2014). Taken together, there appears to be an impact of acute and chronic adapted physical activity on different aspects of EF in adolescents and adults with disabilities, respectively. However, additional studies with larger samples are needed to verify these results across a broad range of developmental disabilities (i.e., including ASD, DS, and ID). Moreover, the type of exercise, intensity, and duration of exercise over a long period of time need to be examined in a large age range of participants with different developmental disabilities to enable evidence-based exercise prescription.

Exercise Interventions for Individuals with Developmental Disabilities – Effects of PA/Fitness, Functional Mobility/Balance, and EF

A recent systematic review of aerobic, strengthening and combined exercise programs found that exercise improves individuals' overall health and well-being with ID (Bouzas et al., 2019). Moreover, a literature review found that aerobic exercise interventions improved balance, aerobic capacity, and weight in adults with DD (Heller & Sorensen, 2013). In particular, aerobic programs are associated with significant improvements in cardiorespiratory fitness (Cluphf et al., 2001; Wu et al., 2010), strength (Carmeli et al., 2009; Wu et al., 2010), flexibility (Son et al., 2016), mobility (Son et al., 2016), and attention (Ptomey et al., 2018). While these studies are promising, many of these previous studies were non-randomized designs (Carmeli et al., 2009; Cluphf et al., 2001; Son et al., 2016; Wu et al., 2010) and/or did not include a control group (Carmeli et al., 2009; Son et al., 2016; Wu et al., 2010), indicating a need for more rigorous study design to reduce threats to validity.

Many types of aerobic exercise programs have been used to improve overall health in individuals with DD, including cycling, walking, jogging, aquatics exercise, and dance (Bouzas et al., 2019). Zumba® is one form of aerobic exercise common in community settings and with adaptions for different populations (i.e., Zumba® Kids and Zumba® Gold for older adults). Studies have found that Zumba® can improve body weight (Cugusi et al., 2015; Krishnan et al., 2015), aerobic capacity (Donath et al., 2014), balance (Donath et al., 2014), muscle strength (Krishnan et al., 2015), and executive functioning (Caciula et al., 2015) in typically developing older adults.

While Zumba® appears to be effective across different physical and cognitive health domains, only two studies have examined its efficacy with adults with DD (Hilapo et al., 2016; Joseph, 2018). Joseph (2018) examined 46 adults with DD (24 experimental, 22 control) who completed an 8-week Zumba® intervention. Compared to controls, those in the Zumba® intervention group significantly improved their functional mobility (Timed-Up and Go; TUG) and aerobic capacity (6-Minute Walk Test; 6MWT). Another study examined nine adults with DD in a single group, pre-test – post-test design; improvements in flexibility and walking speed were observed after eight sessions of Zumba® (Hilapo et al., 2016). Although these results are promising, neither study examined the impact of Zumba® on balance or EF in adults with DD. Moreover, both studies only included individuals with moderate DD. Additional studies are needed with a rigorous research design, examining a range of physical and cognitive outcomes, and including a large sample of adults with disabilities with varying levels of function.

Specific Aims and Hypothesis

Given the limitations of previous studies, critical knowledge gaps need to be addressed to determine the impact of aerobic exercise programs on relevant functional outcomes in adults with DD. Therefore, the purpose of this study was to build upon previous literature by examining the impact of a virtual 10-week (2x a week; 60-minutes per session) adapted aerobic dance intervention (adapted Zumba®) in adults with DD ages 19.04 - 68.78 (n = 57). To this end, we employed a cross-over design with a 3-month wash-out period in which participants in the intervention also served as controls. The participants were quasi-randomized (to match the level of daily function across conditions) into one of two Zumba intervention conditions: low tempo Zumba® (0.75 speed; n = 23), and high tempo Zumba® (normal speed; n = 21). When participants served as controls, they participated in regular daily activities. Participants completed testing four times: pre- and post-test as the control and pre- and post-test as the intervention group. Changes in functional mobility (TUG), balance (Clinical Test of Sensory Interaction on Balance; CTSIB), aerobic capacity (6MWT), and EF (Flanker) were assessed. During the program, participants' MVPA was measured using wrist-worn accelerometers.

It was Hypothesized That:

1) Compared to the control condition, both adapted Zumba® conditions would show an increase in balance, functional mobility, and aerobic capacity (Condition x Time Interaction). Follow-up *t*-tests would reveal a condition-dependent improvement in these outcomes between pre-test and post-test (High tempo>Low tempo>Controls).

2) Compared to the control condition, both adapted Zumba® conditions would show an increase in EF. Follow-up *t*-tests would reveal a condition-dependent improvement in EF from pre-test to post-test (High tempo>Low tempo>Controls).

3) Compared to the control condition, both adapted Zumba® conditions would exhibit improvement in body composition (Condition x Time interaction). Follow-up *t*-tests would

reveal a condition-dependent improvement in BMI and body fat from pre-to post-test (High tempo>Low tempo).

4) High tempo Zumba® condition would exhibit greater MVPA levels compared to Low tempo condition during the program.

This study addressed a knowledge gap regarding the exercise tempo necessary to confer physical and cognitive health benefits in a large age range of participants with different developmental disabilities. This information is needed to develop evidence-based recommendations for exercise prescription in this diverse population.

Limitations/Delimitations

First, the Zumba® intervention was conducted virtually via live video conferencing software (Zoom). Unfortunately, there were three days affected by technical difficulties, including a partial and complete loss of the video feed. Approximately 13 minutes of total intervention time was lost. In addition, there were technical difficulties when monitoring the participation of each participant using this virtual platform (i.e., participants can move off screen or are blocked by other participants). There were also technical limitations in terms of the ability to maintain participant attention and help them stay on task, which may limit the generalizability of the study to in-person settings. To address these limitations, research assistants visually monitored and annotated the participants' levels of participation during the session. The trained staff at the day programs provided in-person encouragement to maintain participant focus and participation.

Second, distribution of and monitoring of actigraph wear was more difficult without direct supervision by the research staff. While staff at the day programs were trained to attach, remove, and promote actigraph wear during the program, there was actigraph data loss (i.e., participant removed the actigraph, staff did not return the actigraphs in time to charge them, participant refused to wear the actigraph during the session).

Third, participants come from a convenience sample. Some participants were recruited from local day programs for individuals with disabilities who have established partnerships with the Pediatric Movement and Physical Activity Lab. To increase the total number of participants and expand beyond the local community, we recruited a new group of participants with whom we had no previous partnership. This resulted in a larger sample of adults with disabilities than previously published studies.

Fourth, given the study design with two active intervention conditions (low- and high-tempo conditions), two instructors led the program simultaneously. Because of this, there may have been instructor bias (i.e., participants were more engaged/active with one instructor). To reduce potential instructor bias, the instructors taught both the low- and high-tempo conditions, with the instructors swapping halfway through the program. The instructors did not contribute to any of the data collection or analyses.

Lastly, due to COVID-19, all data collection occurred at the day programs and not in the lab. To minimize this impact of environmental distractions and differences across the three locations, all data collection took place in similarly sized rooms with sufficient room for participants to rotate through each assessment without distraction. All equipment was transported to each location, and the same researchers collected data at all three locations.

Chapter 2 – Summary of Literature

Overview, Prevalence, and Significance

Developmental Disabilities (DD) are a group of long-term disabilities that begin before the age of 18 years. They include autism spectrum disorder (ASD), cerebral palsy (CP), Down syndrome (DS), intellectual disabilities (ID), and other similar disabilities. Currently, nearly 17% of children have a DD (Zablotsky et al., 2019). Furthermore, the prevalence of DD has grown from 2009 to 2017; ID and DS have increased by more than 25% (from 0.93% to 1.21%), and ASD has doubled (from 1.12% to 2.49%) over this period (Zablotsky et al., 2019). Simultaneously, the life expectancy of those with DS has also increased into the sixties and for those with ID into their seventies, creating a growing population of older adults with DD (Coppus, 2013).

There is a significant increase in the need for services for this growing and aging population. In particular, beyond services for core symptoms of ASD, an increase in physical health care services is needed given the low PA participation of individuals with autism which may contribute to or exacerbate health issues. Individuals with CP may receive physical therapy and/or adaptive PE/sport supports to enable them to be physically active. Similarly, individuals with ID or DS also often need support in the PA setting (e.g., physical therapy or adaptive PE). However, school-related services for individuals with DD end when they graduate high school or age out of the system at age 21 (IDEA, 2004).

The life expectancy of those with ID and DS has dramatically increased over the last 100 years (Bittles et al., 2002; Glasson et al., 2003; Janicki et al., 1999). Individuals with DS, who were once not expected to live out of their adolescence, are now expected to live in their 60s (Coppus, 2013). Individuals with ID, who were not expected to live into early adulthood, are now expected to live into their -70s (Coppus, 2013). These increases in life expectancy are attributed to better health care and life-saving procedures during childhood (e.g., heart surgery for congenital heart defects; Patja et al., 2000).

Despite the increase in life expectancy, individuals with DS and ID do not live as long as typically developing individuals (Coppus, 2013). This may be attributed, in part, to their poor PA levels (Frey et al., 2008; Hilgenkamp et al., 2012) , poor functional mobility (Cleaver et al., 2009), and obesity (Melville et al., 2007; Segal et al., 2016) leading to secondary health conditions. Oppewal and Higenkamp (2018) examined 900 adults with ID (mean age 42 years) to determine the relationship between physical fitness and mortality (Oppewal & Hilgenkamp, 2019b). This 5-year cohort study revealed that reaction time, manual dexterity, balance, gait speed, grip strength, and cardiorespiratory fitness were related to living through those 5 years regardless of age. This is the first study to directly examine the relationships between motor ability, balance, and fitness with long-term health in those with ID. However, the study was unable to assess whether the differences in motor ability, balance, and fitness were due to participation in physical activity or other biological or environmental factors which may influence long-term health. With that said, these results align with research with the general population (Clegg et al., 2013) and with the guidelines of the American Academy for Sports Medicine (American College of Sports Medicine, 2018) suggesting that physical fitness is key to overall longevity. The key knowledge gap is how to increase physical fitness in this population so that they may reap the immediate and long-term benefits to reduce secondary health conditions and early mortality.

Physical Activity and Fitness in Individuals with DD

In order to increase physical fitness, efforts have been focused on increasing physical activity (PA) and meeting recommended levels of PA. The Physical Activity Guidelines for Americans, 2nd Edition (2019) recommend that in order to be healthy, adults with DD should complete 300 minutes of moderate PA per week spread out over each day of the week. The PA should focus on a mix of activities, including those that improve balance and mobility. Adults with DD are recommended to participate in regular strength training.

There are many ways to evaluate PA levels to determine if an individual meets the recommendations. The gold standard quantitative measurement of PA is via triaxial accelerometers. A study of 42 older adults (ages 45 and older) and 42 younger adults (ages 18-45) with mild to severe ID measured PA via actigraph accelerometers worn for 8 days (Oviedo et al., 2017). Nine participants (21%) met physical activity guidelines of 150 minutes of moderate physical activity per day; seven of these participants were younger adults, while two were older adults. Another study reported that only 6% of the older adults with ID (ages 50-77, n = 35) and 13% of younger adults with ID (ages 20-49, n = 49) met the PA recommendation of at least 30-minute bouts of MVPA per day (Dixon-ibarra & Lee, 2013). In comparison, 33% of typically developing older adults (ages 65-89, n = 34) met the PA recommendation (Dixon-ibarra & Lee, 2013). Taken together, these results suggest that although adults with DD do not meet PA guidelines, there is further age-related decline in PA levels in this population.

Another quantitative measure of PA is via pedometers which measure step counts. One suggestion for meeting the recommended PA is to have a step count of 10,000 steps a day (Duncan et al., 2018; Le-Masurier et al., 2003). Using this standard, Hilgenkamp et al. (2012) assessed if older adults with ID (ages 50-89) met this threshold. Only 39% of the 257 participants exceeded 5,000 steps a day (Hilgenkamp et al., 2012). This is consistent with Dixon-

Ibarra & Lee (2013), who examined 109 young adults with and without ID (ages 20-89) using pedometers worn for seven consecutive days. The young adults with ID (ages 20-49) averaged 6,031 steps per day, while the older adults with ID (ages 50-77) only averaged 4,552 steps a day. Both of these articles support that individuals with disabilities not only fall short of the recommended PA, but that older adults with disabilities fall even shorter of the threshold to improve health.

Although quantitative measures, like accelerometers and pedometers, provide unbiased estimates of PA, several studies have used survey-based measures to estimate PA in this population. For example, Stancliff and Anderson (2017) surveyed over 8,636 adults with mild to severe DD and found that while 30% of typically developing adults achieved the recommended PA (150 minutes of moderate to vigorous PA), only 13.5% of those with DD meet those recommendations. In another survey of 788 participants with ID (ages 11-92) reported their PA levels over the last month and overall quality of life; 42% reported never exercising, while only 27% reported regularly exercise of more than 11 times a month (Stancliffe & Anderson, 2017). Consequently, those who exercised regularly reported having a higher quality of life (Blick et al., 2015). However, this result is correlational and there may be many factors, including level of function and independence that may link PA and quality of life.

In summary, regardless of the measurement, individuals with DD need substantially more PA to meet PA guidelines. Although all individuals with DD appear to fail to meet PA guidelines, older adults fall even shorter of the mark. In addition to impacting their health outcomes, correlational data from Blick and colleagues (2015) suggests a relationship between PA and quality of life. Therefore, interventions are needed to enable adults, especially older adults with DD, to achieve PA daily.

Functional Mobility and Balance Difficulties in Individuals with DD

Poor mobility and balance can lead to falls and injuries (Enkelaar et al., 2012), as well as prevent individuals from performing the tasks of daily living (Cleaver et al., 2009). Moreover, falls may be related to increased mortality rates for individuals with ID (Tyrer et al., 2007). Individuals with DD face consistently poor mobility (Cleaver et al., 2009) and balance difficulties (Ahmadi et al., 2019). For example, a survey of 128 caretakers of older adults with DD ages 45-74 found that 59% reported that mobility limitation was present (Cleaver et al., 2009). Moreover, 44.5% would not be able to walk 3 blocks, and 37.5% would not be able to stand for 20 minutes if needed. In comparison, only 13% of typically developing adults ages 45-64 and 23% of typically developing older adults ages 65-74 report mobility concerns (Cleaver et al., 2009). Moreover, poor balance was also reported in older adults with DD by Enkelaar et al. (2012). Specifically, clinical balance tests (e.g., Berg Balance Scale, Single Leg Stand, Timed-Up-and-Go) show that individuals with DD performed outside the typical range of balance scores. Thus, these results demonstrate a clear need for interventions aimed at increasing mobility and balance in adults, especially older adults with DD.

To this end, several studies have shown that exercise increases mobility and balance in adults with DD (Ahmadi et al., 2019; Carmeli et al., 2002, 2005a). For example, a study of 13 men with DS (22-28 years old) examined functional walking training on balance. The participants were split into an experimental group (n = 7) who participated in a 60-minute treadmill walking program for 6-weeks and a control group (n = 6). After 6-weeks of training, the intervention group improved on average from 6.18 seconds to 13.06 seconds on the Stork Balance Test (a test of static balance), while the control group showed no significant changes (Ahmadi et al., 2019). While these results provide additional support that may improve balance in this population, the sample was small, only comprised of men, and only measured static balance (which may not translate to functional mobility/dynamic balance).

To determine the impact of a 6-month walking program (3x/week starting at 15 minutes/session and up to 45 minutes/session) on balance and functional mobility, Carmeli et al., (2002) examined performance of 26 older individuals with DS (*M* age = 63 years) on the Timed Up and Go (TUG). The experimental group was 9% faster after the intervention (decreased TUG time), while the control group showed no significant change in TUG performance over the 6-month period. In a follow-up by a study on 22 individuals ID (ages 55-66), participants completed a similar 6-month training program (3x/week, 45 minutes/session). Once again, the experimental group significantly decreased their TUG time (Carmeli et al., 2005). Both of these studies indicate that a 6-month low-intensity program can improve functional mobility in older adults with DS or ID. However, the long-term benefits of this program are unknown (i.e., how long are improvements retained).

Moderate-intensity aerobic programs have been examined with respect to their impact on functional mobility. For example, (Joseph, 2018) examined the effects of Zumba® on functional mobility (TUG) in 46 participants with DD ages 20-80. The program consisted of Zumba® three times a week for eight weeks at a moderate intensity. The participants significantly decreased their TUG time by about 4 seconds after the intervention (34% improvement). Although the study demonstrates the feasibility of using a higher-intensity aerobic programs in young and older adults with DD, the study design (i.e., no control group) reduces the validity of these results. With that said, in contrast to the low-intensity (walking) programs, the results from the Zumba® program were observed in a much shorter period of time (i.e., 8 weeks compared with 6 months). Therefore, it would be useful to determine if a lower-tempo Zumba® program (i.e., light-to-moderate) results in similar outcomes.

Overall, there is a clear need to improve balance and mobility in individuals with DD. There is a growing body of evidence that light- and moderate-intensity exercise improves mobility/balance in this population. However, more research with larger groups, strong study design, and clear comparison between levels of exercise intensity is needed.

Executive Functioning and Exercise or Physical Activity in Individuals with and without DD

Two important meta-analyses have been conducted examining the relationship between physical activity and cognitive function in typically-developing older adults (Colcombe et al., 2004; Northey et al., 2018). Colcombe and Kramer (2004) were one of the first to determine the specific relationship between aerobic exercise and different domains of cognition, including executive function. They found that across 18 studies, physical activity was positively related to cognition (e.g., executive function, visuospatial skills, processing speed). In particular, the effect sizes for the relationship between PA and EF were the largest across all domains. The authors suggested that participating in PA may attenuate age-related declines in EF. Building upon this study, Northey et al. (2018) examined both acute and chronic effects of different exercise modalities (e.g., aerobic and strength training) on cognitive function. A total of 36 studies were examined that included typically developing adults 50 years and older. One key finding is that the exercise duration needed to be at least 45 minutes per session to significantly impact cognitive function in this population. Taken together, these studies suggest that participation in structured exercise programs can improve important aspects of cognitive function in healthy older adults.

Many studies have been conducted with typically developing older adults to suggest that fitness and/or exercise is positively related to executive function (Colcombe et al., 2004). For example, one foundational study (Colcombe et al., 2004) examined 41 older adults (mean age 66.5) and showed that higher physical fitness was associated with higher attention scores on the Flanker Attention Test.

As mentioned above, individuals with DD have poorer fitness and lower levels of physical activity participation (Dixon-ibarra & Lee, 2013; Oviedo et al., 2017; Stancliffe & Anderson, 2017). In addition, individuals with DD (mean age 15.4) exhibit worse executive function (i.e., including attention, working memory, and response inhibition), than their typically developing peers (der Molen et al., 2007). These deficits may carry over into adulthood and worsen with age. Moreover, deficits in EF may impact independent performance activities of daily living, particularly those requiring purposeful planning and goal-directed action (Lezak, 1982). Thus, it is necessary to determine ways to improve EF, especially for older adults with DD.

Given that EF is especially critical for aging individuals with DD, one study of 84 adults with DS (mean age 49.2) or ID (mean age 53.6) examined memory loss/dementia and found an age-related decline in EF (Devenny et al., 2000). Similarly, in a study of individuals with DS (*n* = 30; mean age 44.5), EF declines were present in those approaching age 50 (Adams and Oliver, 2010). Given the importance of EF to daily living, attenuating decline in EF is critical for this population to maintain independence. However, the long-term effects, type of exercise, and intensity of exercise need to be examined in a large age range of participants with different developmental disabilities to enable evidence-based exercise prescription for this population.

Exercise Interventions in Individuals with DD – Effects on PA, Fitness, Functional Mobility, Balance, and EF

To determine the effects of an *acute* bout of physical activity on executive function, Chen et al. (2016) tested 19- to 25-year-olds with DS who completed either a single bout of high, moderate, or no bout of walking. After an acute bout of exercise, both the moderate and high exercise groups showed a significant increase in performance of an attention switching task(Chen & Ringenbach, 2016). Another study, conducted by Ringenbach et al. (2014) examined the effects of acute bouts of assisted cycling at a preferred intensity on cognitive functioning in individuals (ages 14-25) with DS (*n* = 9). Assisted cycling was associated with improved reaction time and cognitive planning compared to voluntary cycling or no cycling. These studies suggest that different forms of aerobic exercise can acutely improve cognitive function, including executive function in adolescents and young adults with DD. However, the acute effects of these exercises have not been examined in older adults with DD.

To determine the effects of chronic physical activity participation on executive function, Chen et al. (2019) tested young adults with and without ID (*n* = 12, *M* age = 22.83) who completed a 15-week (twice a week, 50 minutes per session) adapted soccer program. While they did not observe improvements in working memory (Corsi Block Tapping Task), improvements were observed for the selective attention task (Flanker) (Chen et al., 2019). Another study (Pastula et al., 2012), examined the effects of adaptive dance intervention on cognitive function in 16 young adults with ID (mean ages: 19.4). Participants completed an 8-week (3 sessions per week, 45 minutes per session) aerobic dance and fitness intervention at a moderate intensity level. Significant improvements were observed in all components of the Woodcock-Johnson III Test of Cognitive Ability (i.e., visual matching, decision speed, pair cancellation, processing speed). Taken together, consistent with the findings from acute exercise studies, chronic exercise participation is associated with improved cognitive function including executive function in adolescents and young adults with DD. However, the chronic effects of these exercise have not been examined in older adults with DD.

There are critical knowledge gaps regarding the effects of acute and chronic exercise on cognitive function across a broad range of ages and developmental disabilities (i.e., including ASD, DS, and ID). Although several studies have examined the physical health outcomes of acute and chronic exercise in individuals with DD, few studies have systematically investigated the impact of various aspects of the exercise (i.e., frequency, intensity, type, and time) on physical health, functional mobility, and cognitive function. Future studies should aim to address the FITT (Frequency, Intensity, Type, Time) principle in this population to determine the most effective and appropriate exercise characteristics for this population.

Chapter 3 – The Effects of Low-Tempo and High-Tempo Zumba® in Individuals with Developmental Disabilities

Introduction

The term developmental disability (DD) encompasses a group of long-term disabilities that begin before the age of 18 years and include autism spectrum disorder (ASD), cerebral palsy (CP), Down syndrome (DS), intellectual disabilities (ID), and other disabilities. Nearly 17% of children in the United States(US) are diagnosed with a DD. Furthermore, the prevalence of DD has increased from 2009 to 2017; ID and DS have diagnoses increased by more than 25% (from 0.93% to 1.21%), and ASD has doubled (from 1.12% to 2.49%) over this period (Zablotsky et al., 2019). Simultaneously, the life expectancy of those with DS has also increased into the sixties and for those with ID into their seventies, creating a growing population of older adults with DD (Coppus, 2013). However, despite the increase in life expectancy, individuals with DS and ID do not live as long as typically developing individuals (Coppus, 2013) and have a lower quality of life throughout the lifespan (Blaskowitz et al., 2020). Therefore, interventions are needed to improve the health and quality of life in adults with DD.

Individuals with DD face disproportionate physical health problems compared to their typically developing peers (de Winter et al., 2015; Rimmer et al., 2010). For example, low cardiorespiratory fitness (Oppewal et al., 2013), low physical activity (PA) levels (Frey et al., 2008; Hilgenkamp et al., 2012), poor functional mobility (Cleaver et al., 2009), and greater obesity (Melville et al., 2009; Segal et al., 2016) are consistently reported. Together, these issues lead to secondary health conditions that contribute to early morbidity and reduced quality of life for the growing population of adults with DD (Rimmer et al., 2007). Moreover, Landes et al., (2020) found that two of the leading causes of death for individuals with DD, heart disease and diabetes, were correlated with low levels of PA Therefore, programs aimed at increasing physical activity (PA) may be associated with improved physical health outcomes and reduction in early morbidity.

Indeed, access to adapted PA and fitness programs may attenuate the risk for health problems, poor quality of life, and early morbidity in this population (Oppewal & Hilgenkamp, 2019)., Older adults (> 50 years old) with ID with high fitness skills (i.e., cardiorespiratory fitness, grip strength, balance) have much higher survival rates over a 5-year period than those with low fitness skills (Oppewal & Hilgenkamp, 2019). Programs aimed at increasing aerobic function and muscle strengthening have been found to improve overall health and well-being in adults (ages 18-75 years) with ID (Bouzas et al., 2019). Thus, there is a clear need to develop and implement adapted PA and fitness programs to promote healthy aging and reduce physical health disparities in this underserved population (Heller & Sorensen, 2013).

However, several significant limitations suggest the need for further study. First, while many previous studies of adapted PA programs have been found to improve cardiorespiratory fitness (Cluphf et al., 2001; Wu et al., 2010), strength (Carmeli et al., 2009; Wu et al., 2010), flexibility (Son et al., 2016), mobility (Joseph, 2018; Son et al., 2016), and attention (Ptomey et al., 2018), few have comprehensively studied these variables (i.e., most examine one or two outcomes). Second, of these studies, only two (Bouzas et al., 2019; Lai et al., 2020) implemented a high-quality research design (i.e., randomized control designs), which reduces the generalizability and increases study bias. Third, of these studies, only two have examined functional mobility or balance (Joseph, 2018; Son et al., 2016) and only one examined attention (Ptomey et al., 2018). These variables are relevant for the ability to perform activities of daily living independently. Fourth, no studies have included a retention period to examine the long-term impact of aerobic exercise programs (i.e., beyond the immediate effects of the programs) in this population. Fifth, no studies have used active control or comparison groups. Active comparison groups are needed to determine how different exercise program components (e.g., frequency, intensity, time, or type) impact outcomes. Lastly, only two studies examined the impact of cognitively-engaging aerobic exercise programs like Zumba® in adults with DD (Hilapo et al., 2006; Joseph, 2018). Cognitively-engaging aerobic exercise programs may have a greater impact on cognitive functions like attention than typical aerobic exercise programs (e.g., running, cycling, etc.).

Given the limitations of previous studies, critical knowledge gaps need to be addressed to determine the impact of aerobic exercise programs on relevant functional outcomes in adults with DD. Therefore, the purpose of this study was to build upon previous literature by examining the impact of a virtual 10-week (2x/week; 60 minutes/session) adapted aerobic dance intervention (adapted Zumba®) in adults with DD ages 19.04 - 68.78 (n = 57). To this end, I employed a cross-over design with a 3-month wash-out period in which participants in the intervention also served as controls. The participants were quasi-randomized (to match the level of daily function across conditions) into one of two Zumba® intervention conditions: low tempo Zumba® (0.75 speed; n = 23), and high tempo Zumba® (normal speed; n = 21). When participants served as controls, they participated in regular daily activities. Participants completed testing four times – pre- and post-test as a control and pre- and post-test following the intervention. Changes in functional mobility (TUG), balance (CTSIB), aerobic capacity (6MWT), and EF (Flanker) were assessed. During the program, MVPA was measured using wrist-worn accelerometers for participants in the intervention conditions.

It was hypothesized that:

1) Compared to the control condition, both adapted Zumba® conditions would show an increase in balance, functional mobility, and aerobic capacity (Condition x Time Interaction). Follow-up *t*-tests would reveal a condition-dependent improvement in these outcomes between pre-test and post-test (High Tempo>Low Tempo>Controls).

2) Compared to the control condition, both adapted Zumba® conditions would show an increase in EF. Follow-up *t*-tests would reveal a condition-dependent improvement in EF from pre-test to post-test (High Tempo>Low Tempo>Controls).

3) Compared to the control condition, both adapted Zumba® conditions would exhibit improvement in body composition (Condition x Time interaction). Follow-up *t*-tests would reveal a condition-dependent improvement in BMI and body fat from pre-to post-test (High Tempo>Low Tempo>Controls).

4) The High Tempo Zumba® condition would exhibit higher percentage of time spent in MVPA during the program than the Low Tempo condition.

Methods

Participants

Participants were recruited from three day programs for adults with DD in the southeast US. The programs were recruited through developing partnerships for exercise programming. The participants were recruited through recruitment letters. All interested families were invited to meet with the researchers via zoom to understand further, their part in the program. The criteria for participation in the day programs included: independent toileting, ability to follow two-step directions, and does not exhibit aggressive or self-harm behaviors. Participants were included in the study if they were healthy enough to participate in exercise (based on the

Physical Activity Readiness Questionnaire or a physician's letter), 18 years or older, and had a diagnosed DD (e.g., autism spectrum disorder, Down syndrome, intellectual disability, etc.). IQ was not available for each participant. All study procedures were approved by the Institutional Review Board at Auburn University (#19-169; Appendix A). Parents and guardians provided informed consent, and participants provided verbal assent to participate in the study. Three individuals do not require guardianship and therefore provided their own consent.

Table 1 provides the details for the participants. A total of 44 individuals (23 males, 21 females) with DD ages 20.8 - 69.2 ($M = 35.8$) years were recruited from three local day programs for adults with DD. A total of seven had ASD, nine had DS, 25 had ID, and three had CP based on parent or guardian reports provided to the day programs. The estimated level of independent function was reported by the day programs based on the following criteria: level of receptive communication, independent mobility, ability to follow directions, level of daily participation, and level of support from staff. The participants were categorized as “low”, “medium,” and “high”.

Table 1. Participant Details

ID	Conditions	Disability	Sex	Age	Estimated Independent Functioning
ZUM01	Fast	ASD	F	46.77	Medium
ZUM02	Fast	ASD	M	27.53	Medium
ZUM03	Fast	ASD	M	25.82	Low
ZUM04	Fast	ASD	M	20.81	High
ZUM05	Fast	CP	F	40.3	Low
ZUM06	Fast	DS	F	47.38	Low
ZUM07	Fast	DS	M	28.36	Medium
ZUM08	Fast	DS	M	27.26	Medium
ZUM09	Fast	DS	M	34.04	High
ZUM10	Fast	ID	F	26.61	Medium
ZUM11	Fast	ID	F	30.35	Medium
ZUM12	Fast	ID	F	27.6	High

ZUM13	Fast	ID	F	29.24	High
ZUM14	Fast	ID	F	27.24	High
ZUM15	Fast	ID	F	31.46	Low
ZUM16	Fast	ID	F	43.6	Medium
ZUM17	Fast	ID	M	53.64	Medium
ZUM18	Fast	ID	M	21.47	Medium
ZUM19	Fast	ID	M	69.26	Medium
ZUM20	Fast	ID	M	32.16	High
ZUM21	Fast	ID	M	43.39	High
ZUM22	Slow	ASD	F	37.85	Low
ZUM23	Slow	ASD	F	23.16	High
ZUM24	Slow	ASD	F	36.31	Medium
ZUM25	Slow	CP	F	40.63	Low
ZUM26	Slow	CP	M	22.55	Medium
ZUM27	Slow	DS	M	27.92	High
ZUM28	Slow	DS	M	25.37	Low
ZUM29	Slow	DS	M	31.59	High
ZUM30	Slow	DS	M	47.2	Low
ZUM31	Slow	DS	M	40.89	High
ZUM32	Slow	ID	F	59.99	High
ZUM33	Slow	ID	F	33.81	Medium
ZUM34	Slow	ID	F	42.08	High
ZUM35	Slow	ID	F	37.93	High
ZUM36	Slow	ID	M	30.83	High
ZUM37	Slow	ID	M	23.99	Medium
ZUM38	Slow	ID	M	30.72	Medium
ZUM39	Slow	ID	M	31.94	Medium
ZUM40	Slow	ID	M	25.18	Medium
ZUM41	Slow	ID	M	59.23	High
ZUM42	Slow	ID	M	39.15	Medium
ZUM43	Slow	ID	M	31.16	Medium
ZUM44	Slow	ID	M	61.88	Medium

Study Design

The study examined the impact of a 10-week (2x a week; 60 minutes per session) virtual adapted aerobic dance intervention (adapted Zumba®). A cross-over design study with a 3-month wash-out period was implemented. Half of the participants completed the intervention in the Spring and subsequently served as controls for the Fall and the other half served as controls in the Spring and completed the intervention in the Fall. Spring or fall was selected at the convenience of the day programs (two programs in the spring, 1 in the fall) Spring or fall was selected at the convenience of the day programs (two programs in the spring, 1 in the fall) There was a 3-month wash-out period between the Spring and Fall programs. Participants were quasi-randomized into the two intervention conditions (low-tempo Zumba®, and high-tempo Zumba®) based on relevant demographics (i.e., level of function, age, and diagnosis). All participants also participated in a control condition (normal activities). The low tempo Zumba® (0.75 speed) included 23 participants, and the high tempo Zumba® (normal speed) included 21 participants. Participants completed testing four times – pre- and post-test as a control and pre-and post-test following the intervention. This design enabled us to determine the overall effects of Zumba® and the impact of tempo level on outcomes.

The adapted Zumba® program was administered for 10-week (2x/week; 60 minutes/session) during the Spring and Fall semesters via Zoom. Two certified Zumba® instructors led the sessions. Both instructors had experience working with children and adults with DD. The instructors swapped conditions halfway through the program to reduce potential instructor bias. Each session consisted of a warm-up (3-5 minutes), 4-5 songs with instruction (40 minutes), and a cool-down (5 minutes) for about 60 minutes, including rest/water breaks and time to transition. The only difference between the two adapted Zumba® conditions was the tempo at which the songs played and the number of times through each song. The songs for the low-tempo condition were set to 0.75-speed. The songs for the high-tempo condition were played at full speed; the songs in the high-tempo condition were repeated to ensure an equal amount of time moving for both conditions. The list of songs is included in Appendix C. All sessions were video-recorded and examined for fidelity. Participants participated in normal activities as part of their day program when they served as controls. Participants were included if they attended 50% or more of the sessions. All participants wore a wrist-worn triaxial accelerometer during each session to ensure participation in the program. Sessions were recorded to provide fidelity.

Data Collection

A team of four researchers was used to collect the data. The researchers underwent 4 hours of training on the data collection tools before testing. All four had at least two years of previous experience working with individuals with developmental disabilities. The training included using the tool, data collection script, and practice.

The data were collected at the three programs. The lead researcher completed site visits before data collection. The researcher assessed the space to ensure each site was similar. Each site gave the participant plenty of room and a quiet space to complete the testing. The team of researchers and the tools were transported to each site.

All participants completed the pre-test one week before the intervention and the post-test one week after the intervention on Monday, Tuesday, or Thursday. The same researcher completed each data collection during pre and post-test. The time of day for each participant was closely matched to the pre-test data collection time. Participants would complete all tests (6MWT, TUG, Flanker, CTSIB, Weight) during their timeslot. All participants were given verbal instructions and visual examples of completing the task.

Dependent Measures

Timed-Up-and-Go (TUG). TUG is a measure of functional mobility. The test consists of the participant sitting in a chair, rising from the chair, walking 3 meters to a cone, turning around, walking back, and returning to sitting in the chair. The total time to complete each trial is recorded. Participants completed the three trials - one practice trial and two formal trials. The average of the two formal trials was used in the present analysis. This test is valid for individuals ages 16-70 years (Blomqvist et al., 2012; Enkelaar et al., 2013), has high test-retest reliability (confidence interval = 0.92; Blomqvist et al., 2012), and has been used with adults with DD ages 20-80 years (Joseph, 2018). Three trials were given to each participant. One trial was practice. The other two trials were averaged together.

6-Minute Walk Test (6MWT). The 6MWT is a submaximal exercise test for the cardiorespiratory functioning (Guerra-Balic et al., 2015). The test includes a measure of pre- and post-walk blood pressure, heart rate, blood oxygen levels, and an estimate of fatigue (Borg Scale). The test consists of walking back and forth between two cones set up 15-meters apart for 6 minutes. The total distance walked in meters was recorded for a single trial and was used for the present analysis. This test is valid for individuals ages 16-80 years (Guerra-Balic et al., 2015), has high test-retest reliability (confidence interval = 0.96; Guerra-Balic et al., 2015), and has been used with adults with DD ages 20-80 years (Joseph, 2018). If a participant needed someone to walk with them, a researcher would walk slightly behind them, so the participant set the pace.

Biodex Balance SD – Modified Clinical Test of Sensory Interaction on Balance (CTSIB). The Biodex Balance SD measures the changes in the center of pressure (sway) while the participant stands on the platform during balance tasks. The Modified Clinical Test of Sensory Interaction on Balance (Shumway-Cook & Horak, 1986) was used for the present study. This test has been used with adults with developmental disabilities ages 18-22 years (Zur et al., 2013). For this test, the participant stands barefoot with the feet hip distance apart. Postural sway is measured during four conditions (20 seconds per condition): eyes open on a firm surface, eyes closed on a firm surface, eyes open on a foam surface, and eyes closed on a foam surface. A sway score is computed based on the mean sway amplitude for each condition, and a composite sway score is calculated across all four conditions. The composite sway score was used for the present analysis.

NIH Toolbox Flanker Test. The Flanker test is a measure of selective attention and inhibition. The version that is part of the NIH Toolbox is administered on an iPad. For each trial, participants need to respond to the direction of a central arrow and ignore the direction of two flanking arrows to the right and left of the central arrow. The central arrow will be either in the congruent direction (← ← ← ← ← ←) or incongruent direction (← ← → ← ←) with respect to the flanking arrows. The participant selects the direction of the central arrow by touching the corresponding left or right arrow on the iPad shown the stimuli. The participant completes six practice trials and a total of 20 formal trials. The raw score is based on the speed and accuracy of the responses during the formal trials and is converted to an uncorrected standard score (*M* = 100, *SD* = 15). The NIH Toolbox Flanker Test has been normed based on a sample of typically developing children and adults ages 3-85 (Zelazo et al., 2014), has high test-retest reliability (confidence interval = 0.80; Weintraub et al., 2013), and has been used with adults with developmental disabilities ages 5-36 (Hessl et al., 2016). The uncorrected standard score was used for the present analysis.

Body Composition. Body composition was measured using a bioelectrical impedance scale (BIA; DC 430-U, Tanita Corporation. Tokyo, Japan). In addition, participant height was measured using a stadiometer. Prior to data collection, participants were asked to void their bladder. Participants stepped onto the scale barefoot and stood still for about 10 seconds. The scale provides weight, body mass index, body fat percentage, body fat mass, and fat-free mass. For the present analysis, BMI and body fat percentage were examined.

Moderate-to-Vigorous Physical Activity (MVPA). A wrist-worn triaxial accelerometer (ActiGraph GT3X, Pensacola, Florida) was used to measure physical activity levels during each adapted Zumba® session for the low and high tempo conditions. ActiLife (Version) was used to conduct the wear time validation and compute PA levels. The wear time validation algorithm used was Choi (2011), which designates "non-wear time" for 90 minutes of consecutive zero/nonzero counts (Choi et al., 2011). In addition, the cut-points used to determine PA categories as Freedson (2011): light (0-2689 counts per 60 seconds), moderate (2690-6166 counts per 60 seconds), vigorous (6167-9642 counts per 60 seconds), and very vigorous (> 9643 counts per 60 seconds)(Freedson et al., 2011). The wear time validation and Freedson cut points have been used to evaluate PA in adults with disabilities ages 23-72 years (Matthews et al., 2011). The percentage of time spent in PA (light + moderate + vigorous + very vigorous) over the 60-minute session and the percentage of time spent in Moderate-to-Vigorous (MVPA = moderate + vigorous + very vigorous) were examined for one session early during the intervention and one session late during the intervention. The early (n = 37/44) and late (n = 36/44) sessions were selected from the first four and last four sessions of the intervention, respectively, to maximize the number of participants contributing data for each session.

Statistical Analysis

For functional mobility, aerobic capacity, balance attention/inhibitory control, and body composition, linear mixed-effect regression (LMER) models were conducted using R Studio (Version 1.1.456– ©2009-2018 R Studio, Inc.) and R (Version 4.1.2 (2021-11-01)). Model selection was used to determine the best fit LMER model with random and fixed effects. The random effects controlled for individual variability across repeated measures (pre-test/post-test intervention vs. pre-test/post-test control). The fixed effects included Conditions (High, Low, Control), Time (Pre-test, Post-test), Group (Fall, Spring), and interactions amongst these fixed effects. Model selection was based on the significant differences in the fit statistics (AIC, BIC, log-likelihood ratio) from one model to the next by incrementally adding random effects, then fixed effects. Significant main effects and interactions were decomposed using follow-up *T*-tests. The level of significance was set to $p < .05$ for all analyses.

Results

All participants were present for at least 50% of the sessions, with an average attendance of 85%

Table 2 includes the means and standard error for each dependent variable by Tempo and Time.

Table 2

Means and Standard Errors by Dependent Variable by Tempo and Time

Dependent Variable	Control Pre-test	Control Post-test	Low Tempo Condition Pre-test	Low Tempo Condition Post-test	High Tempo Condition Pre-test	High Tempo Condition Post-test
TUG	10.5 (0.8)	10.2 (0.8)	10.5 (0.9)	8.5 (0.8)	10.5 (0.9)	8.6 (0.9)
6MWT	386 (14.9)	379 (14.9)	393 (16.1)	424 (16.1)	364 (16.3)	400 (16.3)
CTSIB	2.2 (0.2)	2.1 (0.2)	2.84 (0.2)	2.81 (0.2)	1.8 (0.2)	2.0 (0.2)
% Body Fat	28.0 (1.7)	27.8 (1.7)	27.9 (1.83)	26.6 (1.81)	28.9 (1.81)	28.4 (1.81)
BMI	28.3 (1.0)	28.5 (1.0)	28.3 (1.0)	28.6 (1.0)	28.7 (1.0)	28.6 (1.0)
PA			78.6 (8.1)	72.2 (7.6)	78.1 (14.1)	79.6 (8.20)
MVPA			38.4 (7.87)	42.5 (12.9)	26.6 (6.92)	35.3 (10.1)

^{a} Pre-test vs. Post-test - $p < 0.05$

^{b} Control vs. Low Condition- $p < 0.05$

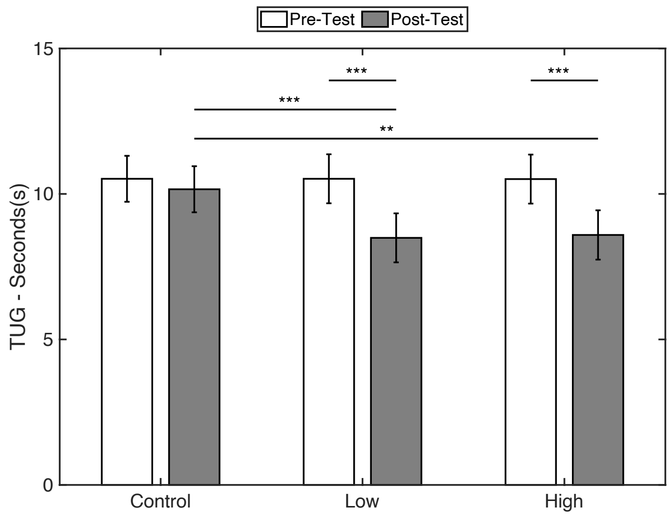
^{c} *t*-Test Control vs. High Condition- $p < 0.05$

^{d} *t*-Test Low Tempo vs. High Condition- $p < 0.05$

Appendix D includes the means and standard deviations for each dependent variable by Condition and Time. For the TUG, significant main effects of Condition ($F(2, 125) = 5.487$, $p < .005$), Time ($F(2, 122) = 31.519$, $p < .001$), and a Condition x Time interaction ($F(2, 122) = 5.601$, $p < .005$) were found. Post-hoc analysis of the interaction revealed that the low tempo condition ($t(110) = 4.211$, $p = .001$, $d = 1.291$) and high tempo condition ($t(108) = 3.878$, $p = .001$, $d = 1.208$) took significantly less time to complete the TUG at post-test than pre-test; no such improvement was observed for the control condition ($t(109) = -1.022$, $p = .309$, $d = 0.220$). Moreover, the high tempo condition was not significantly different from the control condition at pre-test ($t(93) = 0.011$, $p = .999$, $d = 0.003$), but took significantly less time to complete the TUG than the control condition at post-test ($t(96) = 3.394$, $p = .003$, $d = 0.988$). Similarly, the low tempo condition was not significantly different than the control condition at pre-test (t (95) = -0.043, $p = .999$, $d = 0.012$), but took significantly less time to complete the TUG than the control condition at post-test ($t(96) = 3.704$, $p = .001$, $d = 1.055$). There were no differences between the high and low tempo condition at pre-test ($t(112.3) = -0.042$, $p = .999$, $d = 0.016$) or post-test ($t(113) = 0.017$, $p = .983$, $d = 0.007$).

Figure 1

Timed Up and Go - Functional Mobility



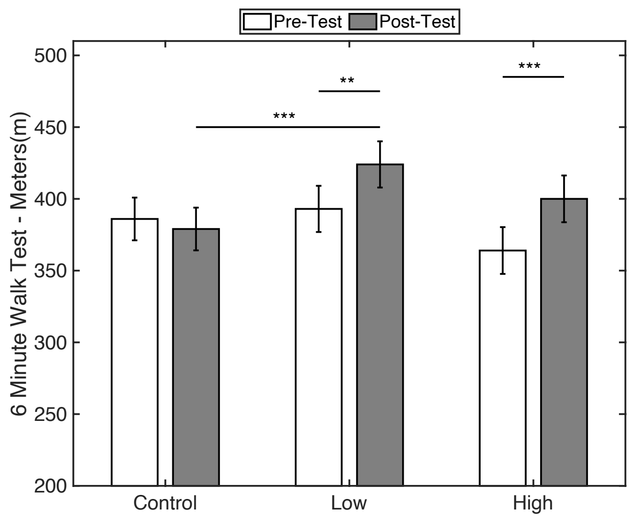
Note. Means and standard errors are presented. The lines represent the posthoc comparisons. $^{**}p < .01$, $^{***}p < .001$.

For the 6MWT, significant main effects of Condition ($F(2, 125) = 6.175$, $p < .005$), Time ($F(2, 122) = 12.908$, $p < .001$), and a significant Condition x Time interaction ($F(2, 122) = 7.328$, $p < .001$) were found. The low tempo condition ($t(109) = 2.997$, $p = .003$, $d = 0.919$) and high tempo condition ($t(108) = 3.274$, $p = .001$, $d = 0.368$) walked further at post-test than pre-test; no such improvement was observed for the control condition ($t(108) = 0.927$, $p = .356$, $d = 0.202$). The low tempo condition was not different than the control condition at pre-test ($t(95) = -0.658$, $p = .788$, $d = 0.188$) but walked further than the control condition at post-test ($t(96) = 4.597$, $p < .0001$, $d = 1.308$). The difference between the high tempo condition and the control condition approached conventional statistical significance at pre-test ($t(93) = 2.213$, $p = .070$, $d = 0.638$) and with no significant differences ($t(93) = 2.028$, $p = .111$, $d = 0.602$) at post-test . Further, high tempo condition and the low tempo condition approached conventional statistical significance

($t(112) = 2.202$, $p = .075$, $d = 0.825$) with no significant differences ($t(115) = 1.864$, $p = .154$, $d = 0.707$) at post-test.

Figure 2

6 Minute Walk Test - Cardiorespiratory Fitness

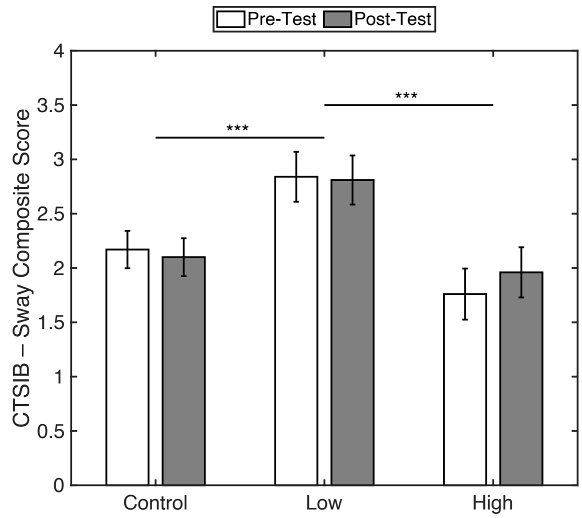


Note. Means and standard errors are presented. The lines represent the posthoc comparisons.
** $p < .01$, *** $p < .001$.

For the CTSIB, a significant main effect of Condition ($F(2,140) = 9.993$, $p < .001$) was observed. The low tempo condition exhibited greater overall sway during the balance test compared to the high tempo condition ($t(98) = 3.956$, $p < .001$, $d = 0.817$) and control condition ($t(101) = 4.089$, $p < .0005$, $d = 1.145$). There was no difference between high tempo condition and control condition ($t(98) = 1.548$ $p = .273$, $d = 0.329$). There was no significant main effect of Time ($F(2,119) = 0.054$, $p = .816$) or a Condition x Time interaction ($F(2,119) = 0.352$, $p = .711$).

Figure 3

CTSIB - Static Balance

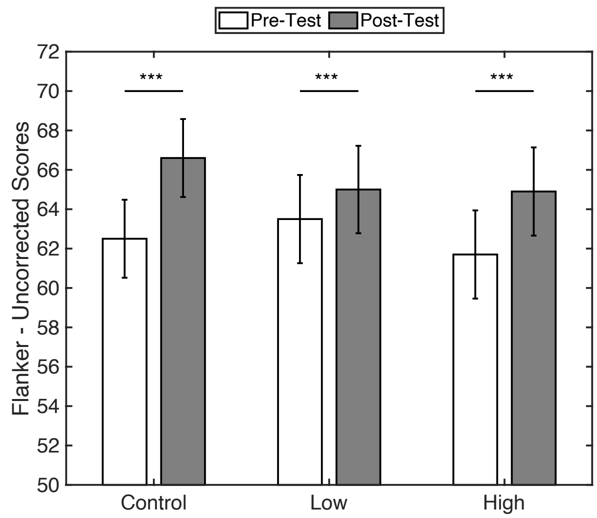


Note. Means and standard errors are presented. The lines represent the posthoc comparisons. *** $p < .001$.

For Flanker, a significant main effect of Time ($F(2,44) = 13.265$, $p < .001$) was observed. The uncorrected standard score increased from pre-test to post-test ($t(43) = 3.639$, $p < .001$, $d = 0.601$) regardless of condition. There was no significant main effect of Condition ($F(2,18) = 0.612$, $p = .544$) or a Condition x Time interaction ($F(2,22) = 0.753$, $p = .474$).

Figure 4

Flanker - Inhibitory Control/Attention

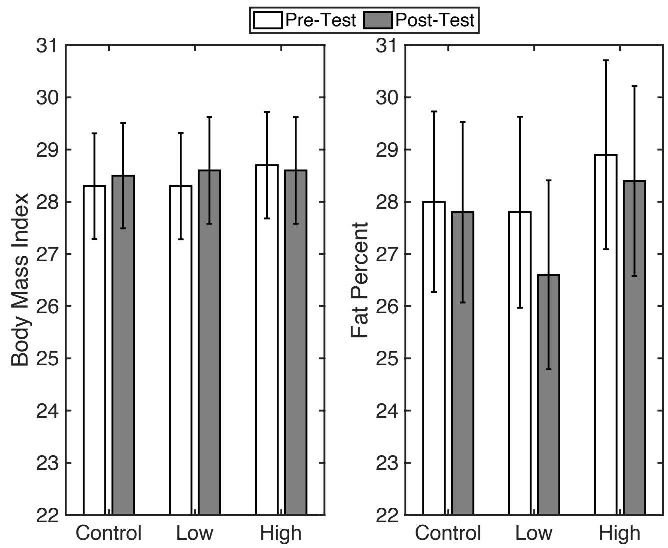


Note. Means and standard errors are presented. The lines represent the posthoc comparisons. *** $p < .001$.

For the body composition measures, there were no significant main effects of Time (F(2,122) = 2.166, p = .144), Condition (F(2,122) = 1.909, p = .152), or a Condition x Time interaction (F(2,122) = 1.005, p = .369) for BMI. Similarly, there were no significant main effects of Time (F(2,122) = 1.790, p = .184), Condition (F(2,122) = 1.570, p = .213), or a Condition Time interaction (F(2,122) = 0.48, p = .619) for Percentage Body Fat.

Figure 5

Body Fat Percentage (Left) and Body Mass Index (Right) - Body Composition



Note. Means and standard errors are presented.

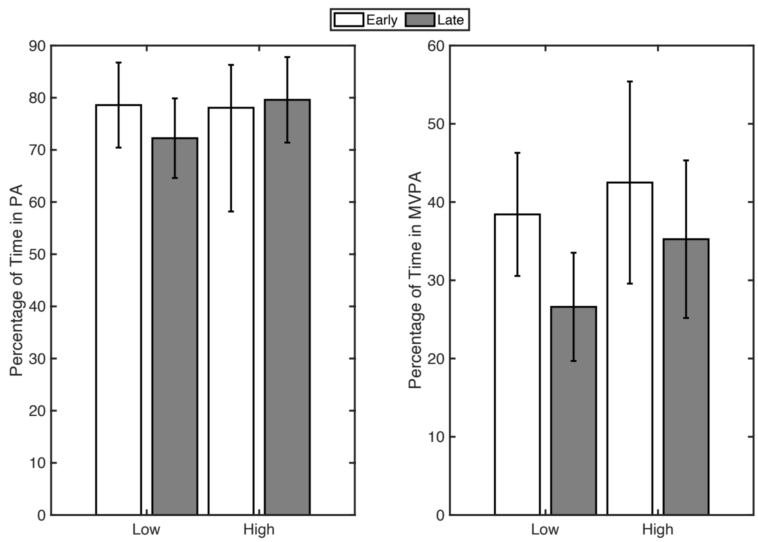
For the PA measures, there were no significant Time (*F*(2,26) = 0.199, *p* = .821) or Condition (Low/High; (*F*(2,26) = 4.334, *p* = .057), or a Condition x Time interaction (*F*(2,26) = 0.677, *p* = .397) for total PA. The average percentage of time spent in PA for the low tempo condition was 78.6% (~47 minutes) early during the intervention and 72.2% (~43 minutes) late during the intervention. The average percentage of time spent in PA for the high tempo condition was 78.1% (~47 minutes) early during the intervention and 79.6% (~48 minutes) late during the intervention.

For MVPA, there were no significant Time (*F*(2,26) = 0.272, *p* = .606) or Condition (Low/High; (*F*(2,28) = 2.762 , *p* = .108), or a Condition x Time interaction (*F*(2,26) = 0.787, *p* = .383).The average percentage of time spent in MVPA for the low tempo condition was 38.4% (~23 minutes) early during the intervention and 26.6% (~16 minutes) late during the intervention. The average percentage of time spent in MVPA for the high tempo group was

42.5% (~26 minutes) early during the intervention and 35.3% (~21 minutes) late during the intervention.

Figure 6

Physical Activity (PA; Left) and Moderate-to-Vigorous Physical Activity (MVPA; Right)



Note. Means and standard errors are presented. n = 37/44 early; n = 36/44 late.

Discussion

The current study is the first of its kind, examining a cognitively engaging exercise program (adapted Zumba®) employing a quasi-randomized control trial with two intervention conditions (high and low tempo) and a control condition in adults with DD. Hypotheses 1 was partially supported with respect to changes in functional mobility and aerobic capacity. Although there was no condition-dependent improvement in functional mobility and aerobic capacity, both intervention conditions exhibited improvements in these outcomes. In contrast, no such improvement was observed for the control condition. The results for the other outcome measures (static balance, MVPA, body composition, and attention) did not support our hypotheses of condition-dependent improvements following the intervention (Hypothesis 1, 2, and 3); the potential reasons are discussed below. Although there were no differences in PA or MVPA between the two Zumba® conditions, the present results support the use of Zumba® as a means to achieve PA. Indeed, participants in these conditions averaged 43-48 minutes of PA per session and 16-26 minutes of MVPA per session. Taken together, this study provides new evidence that Zumba in a virtual format is viable for individuals with DD and that modifying the tempo of the program does not impact the degree of improvement in functional mobility and aerobic capacity resulting from 10-week (2 sessions/week; 60 minutes/session) Zumba program. The present study also adds to the literature by demonstrating similar improvements in functional mobility and aerobic capacity by both the low- and high-tempo conditions. This outcome is important as some participants have difficulty keeping up with the regular music tempo (high-tempo condition in the present study). Therefore, adopting a lower tempo (i.e., 0.75 speed) represents an easy way in which community Zumba® instructors may increase participation and inclusion of adults with disabilities.

Functional mobility is a critical aspect of many activities of daily living (ADLs) (Alexander et al., 2000; Donoghue et al., 2014; Lilja & Borell, 1997; Viccaro et al., 2011). For example, Alexander et al. (2000) found that functional mobility predicted the need for assistance with ADLs in typically developing older adults (60+ years of age). More recent studies have found a positive relationship between the time to complete the TUG task and risk of falls (Donoghue et al., 2014; Viccaro et al., 2011) and difficulties with ADL (Donoghue et al., 2014; Viccaro et al., 2011) in older adults that live independently. Taken together, it would be reasonable to hypothesize that an adaptive Zumba® program would be associated with greater independence in ADLs via an increase in TUG performance.

Despite the relevance of functional mobility to independence and fall risk, only a few studies have measured TUG performance in adults with DD (Cabeza et al., 2019; Carmeli et al., 2003, 2005; Joseph et al., 2018). The TUG performance of the present sample of adults with DD (ages 20.8 - 69.2) at pre-test (*M* = 10.5; *SE =0.80*) is consistent with (Carmeli et al., 2003, 2005b; Joseph et al., 2018). However, the TUG performance of the present sample of adults with DD was poorer than that reported for adults with DS (Cabeza et al., 2019). Additionally, the present study of individuals with DD is comparable to much older, typically developing (Asano et al., 2007; Steffen et al., 2002). Asano (2007) examined 31 older adults (*M* = 77.6 years) who are typically developing that had a TUG score average of 11.9. Steffen (2002) found an average TUG score of 8 (ages 60-69), 9 (ages 70-79), 11 (ages 80-89). Given this information, the present study of adults (ages 20-69) functional mobility scores are similar to those of much older adults (ages 80-89). This could be due to the understanding of the task, their reaction time, or struggling with the transition from standing up to walking. Overall, this study adds to the literature by examining a large range of disabilities, ages, and functioning levels for this measure.

A few studies have examined changes in TUG performance in adults with DD following aerobic exercise interventions (Joseph et al., 2018). The changes in TUG observed in the present study replicate and extend the work by Joseph (2018) with a similar sample and intervention. Specifically, Joseph (2018) reported an average improvement of 1.5-seconds for the TUG following 24 sessions of in-person Zumba® intervention (8 weeks; 3x/week; 60 minutes/session) intervention in a similar sample of adults with DD (M = 42 years). The present study reported an average improvement of 2 seconds for the TUG fewer sessions (20 sessions).

The aerobic capacity performance of the present sample of adults with DD (ages 20.8 - 69.2) at pre-test (*M* = 378.5; *SE =16.2*) is consistent with other studies for those with DS(Casey et al., 2012; Chen et al., 2018) and DD (Joseph et al., 2018). The present study is distinctly different from a study of Special Olympians (ages 18-50) who walked between 524-839 meters (Nasuti et al., 2013). This is likely due to the athletic nature of the participants and the slightly younger populations. Overall, this study adds to the literature by examining a large range of disabilities, ages, and functioning levels for this measure.

The findings for the 6MWT are also a replication and extension of Joseph (2018) examine aerobic capacity. The present study reported an average improvement of about 33.5 meters following 20 sessions of Zumba® while Joseph (2018) reported an average improvement of 22.5 more meters following 24 sessions. The other study examining the efficacy of adapted Zumba® in adults with DD used different measures of aerobic capacity (50-m sprint and 3-minute step test) but also reported significant results for both measures (8 weeks; 3x/week; 60 minutes/session) (Hilapo et al., 2016). Taken together, adapted Zumba® delivered in-person or virtually is an effective way to increase aerobic capacity in adults with DD, better than other aerobic exercise interventions.

This was the first study to measure the improvements in balance using the CTSIB rather than other balance measurements such as Stork Test (Ahmadi et al., 2019), functional mobility/balance (Carmeli et al., 2005; Carmeli et al., 2002), Single Leg Stand (Oviedo et al., 2014). The present results indicate that the 10-week program did not systematically affect static balance. There are several possible explanations for the lack of difference from pre- to post-test for any condition. First, the present dose of the intervention may not have been sufficient to impact static balance or body composition. This is possibly due to Zumba® being dynamic in nature, and improvements in dynamic rather than static balance may have occurred but were not measured in the present study. Moreover, the dynamic balance may be more related to TUG performance. Indeed, previous studies have indicated that TUG is a good indicator of a dynamic balance (Alghadir et al., 2018), and conversely, improvements in balance are associated with a corresponding improvement in TUG. However, future research is needed to assess changes in dynamic balance.

For the attention and inhibitory control test (Flanker), the hypotheses of a condition-dependent increase in performance were not observed. Rather, all participants improved from pre- to post-test. This may indicate that there is a learning effect. Chen et al., (2019) examined a soccer program. They found a trend towards improvements in the Flanker score ($p > .06$). However, this study employed a six-month intervention to obtain only a trend towards improvement. Given the large dose in this intervention, only obtaining a trend towards improvement is more evidence that Flanker may not adequately measure the benefits of exercise. Additionally, Chen et al., (2019) used a smaller (n =10), younger (M= 20.9 years) population. This group of individuals may be less affected by cognitive decline. Given this, the present study adds to the literature through the use of Flanker in an older population with different DD. Given that Zumba® requires selective attention from the instructor, I believed that Zumba® might elicit greater improvements than the adapted soccer program. However, the present results indicate that the 10-week program was insufficient to impact attention. Indeed, soccer skill development may have been a better impact on static attention. Pastula et al. (2012), showed improvements on the Woodcock-Johnson III Test of Cognitive Ability after an 8-week (3 sessions/week, 45 minutes/session) aerobic dance and functional fitness (i.e., air squats, sit-ups) intervention at a moderate intensity level in young adults with ID (M = 19.4 years). There are a few different reasons for the discrepancy between the results from the present study (no effect of the intervention on Cognitive Functioning). First, Pastula et al. (2012) studied a younger population. Given the age difference, the younger population may be less affected by cognitive decline.

Additionally, the Woodcock-Johnson III Test of Cognitive Ability measures a broad range of cognitive functions not limited to EF like our study. This may be a better measure for broadly understanding the changes dance intervention causes in cognitive functioning. Finally, the present intervention dose was slightly lower based on MVPA data (16-26 minutes of MVPA) vs. 45 minutes in the Pastula (2012) study.

Although the present study focused on the *long-term* changes in attention and inhibitory control, it is possible that the Zumba® program may have resulted in *acute* changes. For example, Ringenbach et al. (2014) reported improvements in cognitive function (reaction time and cognitive planning) following an acute bout of assisted cycling in individuals (ages 14-25) with DS (n = 9). In another study, researchers examined acute bouts of treadmill walking (20 minutes incremental intensity) in young adults (ages 16-30) with DS (Chen & Ringenbach, 2016). The results showed that these acute bouts of exercise significantly impacted inhibitory control. Future studies are needed to determine the acute and chronic effects of aerobic exercise on EF.

There was no difference from pre- to post-test in body composition for any condition. There are several possible explanations for this result. First, the present dose of the intervention may not have been sufficient to impact static balance or body composition. Previous adapted exercise interventions (33-96 sessions) that observed changes in body composition differed from the present study (20 sessions) in terms of total dose (Carmeli et al., 2005; Moss, 2009; Wu et al., 2010). Second, with respect to body composition, our study did not control for the nutrient intake of the participants. Future research should control for diet.

Limitations and Future Directions

As with many virtual, community-based programs, there were several limitations due to delivery and technology. First, with respect to delivery, it was difficult to maintain full participation in a virtual format compared to in-person programs. In comparison to in-person programs in which instructors can provide immediate, directed feedback and support to specific participants, this was not possible in a virtual format. Although in-person program staff was available to assist participants during the program, one-on-one support for each participant was not available. Although we could not monitor and enhance each participant's involvement during the sessions, all participants were present for at least 50% of the sessions, with an average attendance of 85%. Second, the quality of the video capture frame was also a limitation. For example, the capture frame was too small to observe all participants simultaneously. Participants moved in and out of the capture frame during the session, which affected the ability to monitor participation. Different participants were visible for each session (i.e., in the foreground vs. background).

Additionally, the video quality was low (i.e., blurry). In the future, high-quality web cameras would need to be provided to community partners and placed in a stable/standard position that enables high-quality video capture for all participants. In addition, participants should be assigned a specific and consistent spot for each session to facilitate behavior coding for each participant. Third, technical issues resulted in some session time lost. For example, three sessions were impacted by technical issues (i.e., Wi-Fi outage, power outage), resulting in a loss of 13 minutes of session time.

In addition to delivery and technology-related issues, COVID-19 safety precautions may have affected performance outcomes. For example, all participants wore masks during the pre-test and post-test assessments. This might have impacted performance on the TUG, 6MWT, CTSIB, and Flanker if the mask led to greater fatigue or discomfort breathing through the mask or affected vision if the mask was not worn correctly or was unstable. Future studies would be needed to verify a negative impact of a mask on these outcomes.

Future studies are needed to determine if a higher dose adaptive Zumba® intervention (i.e., more than 20 sessions) is required in order to significantly impact this population's static balance, body composition, and attention/inhibitory control. Studies are needed to determine the extent to which significant outcomes are retained once participation is discontinued. Lastly, adults with DD with greater cognitive, mobility, or behavioral challenges may require additional supports or adaptations to participate in Zumba® (e.g., pre-teaching the moves, providing additional physical supports, providing additional visual supports). Future studies are needed to determine the efficacy of these supports on functional outcomes and participation for adults with DD with greater needs.

Chapter 4 – General Discussion

Study Significance

The population of individuals with developmental disabilities (DD) is steadily growing (Zablotsky et al., 2019), and life expectancy continues to increase for those with DD. Even as the population grows larger and older, there are still many concerns for aging adults with DD. For example, adults with DD disproportionately experience physical health problems (de Winter et al., 2015). Indeed, low cardiorespiratory fitness (Oppewal et al., 2013), low physical activity (PA) levels (Frey et al., 2008; Hilgenkamp et al., 2012), poor functional mobility (Cleaver et al., 2009), and greater obesity (Melville et al., 2007) are consistently reported. Together, these issues lead to secondary health conditions that contribute to early morbidity and reduced quality of life for the growing population of adults with DD. In addition, many of these health problems affect the ability to independently complete activities of daily living (i.e., bathing, dressing, feeding, etc.). Therefore, interventions addressing these disparities are necessary to help individuals with DD maintain self-determination, autonomy, and independence in daily activities as they age.

Aerobic exercise programs have been found to improve the cardiorespiratory fitness (Cluphf et al., 2001), strength (Carmeli et al., 2009), flexibility (Son et al., 2016), mobility (Son et al., 2016), and attention (Ptomey et al., 2018). However, few studies have comprehensively examined the effects of aerobic exercise programs on different functional outcomes needed to perform activities of daily living. Moreover, there is a need to determine if adjusting exercise parameters (i.e., intensity) to best meet the needs of this population (i.e., cognitive, functional, and mobility differences) affects the efficacy of adapted aerobic exercise programs. The present study aimed to address these knowledge gaps.

To date, two studies examined the impact of a cognitively engaging aerobic exercise program (Zumba®) in adults with DD (Hilapo et al., 2016; Joseph, 2018). Improvements in cardiorespiratory fitness were observed for both studies. Additionally, improvements in flexibility (Hilapo et al., 2016) and functional mobility (Joseph, 2018) were observed. However, both studies employed non-randomized study designs, which increases the risk of bias and reduces internal and external validity. Moreover, these studies did not examine if differences in program parameters (e.g., the tempo of the Zumba® program) affected outcomes.

The present study replicated the effects on functional mobility observed by Joseph (2018) and aerobic capacity observed by Hilapo et al. (2016) and Joseph (2018). Moreover, we examined if there are dose-dependent effects of tempo on a broad range of outcomes. Interestingly, both Zumba® conditions (low and high tempo) improved functional mobility and aerobic capacity, suggesting that reducing the tempo does not affect these outcomes. This is important as some adults with DD may be unable to keep up with the full tempo music (high tempo condition) because of mobility, attention, or other factors. Given the widespread availability of Zumba®, and Zumba® Gold for older adults, which employs slower tempo music, it may be possible for adults with DD to participate in existing community programs and reap the benefits of Zumba® with minimal adaptions (i.e., reducing the tempo). Moreover, as many community programs have adopted virtual formats to provide content delivery during COVID, the present study provides support that adults with DD can access and benefit from available virtual Zumba® programming. Indeed, virtual programming may reduce many of barriers to participation for adults with DD (i.e., transportation, cost, staffing; van Schijndel-Speet et al., 2014).

The present study included eight participants that were rated by the day program staff as having a low independent function (i.e., very limited expressive communication, limited receptive communication, poor mobility, difficulties staying on task, etc.). While qualitative staff ratings are not a standardized tool, these ratings are useful in understanding the range of the independent function of the participants in the present study. The current results suggest that a virtual Zumba® program is accessible to those with similar characteristics. The present study did not include adults with DD with significant cognitive, mobility, or behavioral challenges (i.e., those that require significant one-on-one support to complete most ADLs). Those individuals may require additional supports or adaptations (e.g., pre-teaching the moves, providing additional physical supports, providing additional visual supports) to participate in and reap the benefits of in-person or virtual Zumba® programs.

The present study is novel and innovative in several ways. First, this is the first study to employ a high-quality research design with a large population of adults with disabilities to examine the effects of a cognitively engaging aerobic exercise. Second, this is the first study to examine how differences in exercise program parameters (i.e., music tempo) affect program outcomes. Third, it is the first study to comprehensively evaluate the impact of the intervention on functional mobility, aerobic capacity, balance, executive function, and body composition. Lastly, this is the first study to determine the feasibility and impact of a virtual intervention. Not only do the present results replicate previous studies of in-person Zumba®, but these results suggest that a virtual format is a viable means of scaling access to cognitively engaging aerobic exercise programs for adults with DD. Indeed, adults with DD can easily be included in the existing community-based Zumba® programs (virtual and in-person), especially if the tempo is reduced (e.g., Zumba® Gold).

Future Research Directions

There are several future directions that directly build upon this program of research. Additional studies are needed to examine how other exercise parameters such as frequency, time, and type affect functional outcomes in adults with DD. Given that no changes were found in body compositions, attention, and balance were observed presently; it is possible that a larger intervention dose is needed to impact these variables. It is also possible that a larger intervention dose would be needed to retain functional gains following cessation of exercise. Future research should examine longer interventions and sustained exercise impact on these variables. With respect to exercise type, many studies focus on one type/modality of exercise compared to no exercise conditions. Research is needed to compare Zumba® with aerobic interventions to determine which programs confer the greatest benefit on functional outcomes. Moreover, additional studies are required in order to compare cognitively engaging aerobic exercise programs with resistance-based programs (e.g., weightlifting) or hybrid exercise modalities (e.g., yoga). Programs that integrate exercise and diet modifications confer the greatest impact on obesity-related outcomes. Future studies are needed to determine the effect of integrated diet and exercise programs on these outcomes.

Program Impact

This project enabled me to provide an opportunity for physical activity engagement in a large group of adults with DD during the COVID-19 crisis. Indeed, the virtual delivery method enabled the project to serve participants outside the local region through a new partnership with a day program two hours away. The opportunity pushed me to think critically about leveraging resources to scale up the reach and accessibility of our programs moving forward.

Running a large research project remotely also helped me to learn more about project management. It was vital to be in constant communication with the staff of each program to ensure they had the equipment necessary to participate (i.e., WiFi, cameras, speakers). Constant communication with the staff was needed to ensure all participants were active and engaged during the program for the duration of the ten weeks and to ensure program fidelity. Moreover, managing a research staff of eight undergraduate and graduate students and two instructors provided ample learning opportunities that will lead to my future success in the world of research (e.g., lab management, graduate student mentoring, and project development).

I have become a much more critical, thoughtful, and independent researcher through this process. I learned to critically evaluate the selection assessments and research tools from theoretical and practical perspectives. For example, the balance and attention assessments may not have been adequately sensitive to measure changes due to the intervention. Large-scale virtual projects require considerable planning regarding the technical requirements and setup. For example, two standard web cameras were insufficient to capture 15 participants during the intervention. In addition, camera resolution and placement are important to consider in the future. Finally, conducting research with human subjects, especially those with DD, is a uniquely wonderful and equally difficult endeavor. Researchers need to be thoughtful about effective and consistent communication with participants, ensure that they understand instructions, stay on task, and are motivated to complete each task during the testing and intervention phases. Thoughtful consideration is also needed to evaluate community spaces to reduce distractions during testing and ensure consistency in the testing environment across locations.

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Appendix A:

SCHOOL OF
KINESIOLOGY

AUBURN UNIVERSITY
COLLEGE OF EDUCATION

(NOTE: DO NOT SIGN THIS DOCUMENT UNLESS AN IRB APPROVAL STAMP WITH CURRENT DATES HAS BEEN APPLIED TO THIS DOCUMENT.)

Parent/Guardian Permission

for a Research Study entitled

"The Effects of Adaptive Exercise on Individuals with and without Disabilities"

Your child is being asked to take part in a research study. This research study is voluntary, meaning that your child can participate in the adapted virtual land-based aerobics program but does not have to take part in the research study. The procedures, risks, and benefits are fully described further in the parent/guardian permission form. The purpose of the study is to measure the effects of adaptive virtual land-based aerobics programs with respect to physical activity, sleep, physiological function, balance, functional mobility, attention, and behavior in individuals with and without developmental disabilities. There will be two visits 2 weeks before and after the program each lasting about 1 hour. During these visits, your child will complete a walking test for 6 minutes, complete an attention text (~3 minutes), a balance test (~4-6 minutes), and a functional mobility test (~2 minutes). In addition, your child will wear a monitor on his/her wrist that measures activity levels, sleep, and heart rate for one week. You will also be asked to complete a COVID symptom questionnaire for your child on the day before and day of the testing. For the program, your child will complete a 60-minute adapted virtual land-based aerobics class for ten weeks (20 sessions, twice a week). Your child will wear the same monitor on his/her wrist to measure physical activity, sleep, and heart rate. Your child will be video recorded to measure his behaviors during the sessions. You will also be asked to complete questionnaires about your child's health, communication, behavior, and physical activity readiness. Your child may experience physical fatigue (muscle fatigue and soreness) from the program and physical activities in the pre/post assessments. During the testing sessions, COVID-19 safety guidelines will be followed (e.g., social distancing, decontamination of all equipment, researcher use of face masks, face shields, disposable gloves, disposable lab coat). There is also a risk of a breach of confidentiality. The study is designed to help increase participants' skill levels and physical activity. In addition, the study may have substantial impact on understanding how health-related and behavioral outcomes of programs for individuals with and without developmental disabilities.

The study is being conducted by Dr. Melissa Pangelinan (Assistant Professor), Emily Munn (Graduate Student), and Danielle Carabello (Graduate Student) in the School of Kinesiology at Auburn University.

Parent/Guardian's Initials ______

The Auburn University Institutional Review Board has approved this Document for use from 11/18/2020 to 04/15/2021
Protocol # 19-169 MR 1907

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Your child was selected as a possible participant because:

- Your child is 4-75 years old.
- Your child is participating in an adapted virtual land-based aerobic exercise program.
- There is no reason to believe that your child's participation in exercise and physical activity may put your child's health or well-being at risk (based on the PAR-Q).
    - If there is reason to believe that your child's health or well-being is at risk, your child must receive clearance from a physician.

What will be involved if you participate? If you decide allow your child to participate in this research study, up to two weeks prior to (pre-test) and following (post-test) the program, your child will complete testing at their day program. The day before and day of the testing you will be asked questions about COVID-19 symtoms and exposure. You will also be asked to complete questionnaires about your child's health, communication, behavior, program goals, and physical activity readiness. You child will then complete the 6-minute walk test. For this test, your child will walk back and forth between two cones (15 meters) for 6 minutes. The total distance traveled will be computed and your child will be asked how hard he/she worked during the walk test. In addition, differences in blood pressure, heart rate, blood oxygen level, and breathing rate will be measured using a wrist-worn monitor (similar to a Fitbit or Apple Watch). This monitor will measure his/her physical activity levels and quality of sleep for one week. The monitor will be returned at the first day of the program for pre-test. The monitor will be returned to the School of Kinesiology via mail the week following the post-test (we will provide an addressed envelope with postage). You child will complete a test of inhibitory control and attention (Flanker test) which will be completed on an iPad and will take about 3 minutes to complete. To complete this test, your child will be shown five arrows and will be asked to select an arrow that is in the same direction as the middle arrow. Your child will complete a balance test on the Biodex Balance System. Your child will stand on the platform and the Biodex Balance System will measure how much he/she sways when he/she stands with his eyes open and closed on a firm and foam surface (~2 minutes). He/she will then complete a test in which he/she will control a cursor by leaning his/her body. This test will take between 2 and 4 minutes. Finally, your child will complete functional mobility test in which he/she will stand up from a chair, walk 3 meters, turn around, walking back, and sitting down in the chair. This test will take less than 2 minutes to complete. During the testing, COVID-19 precautions will be taken (see below under Risks for details).

For aerobics program, your child will have a certified aerobics instructor. We will observe your child throughout the program for changes in movement skills. Your child will also wear the wrist-worn monitor to measure physical activity, heart rate, and sleep. We will also video record the sessions to observe your child's behavior during the lessons (e.g., how well your child participates in activities, pays attention during instructions, and works with others).

The land-based virtual aerobic programs will consist of 20 sessions (1 hour each, twice a week) during a ten-week period. The aerobic programs will consist of: 5-minute warm-up and group game, 45-minutes of aerobics (walking, jogging, jumping, dancing), and 10-minute cool-down and group game. The program will be presented on TV screens at our child's day program using Zoom. The total participation time for the adapted aerobics programs is 22 hours.

Are there any risks or discomforts? Participants may experience physical fatigue (muscle fatigue and soreness) from the program and physical activities in the pre/post assessments. To alleviate this fatigue, participants are encouraged (and will be reminded) to take breaks at any time or stop participating all together. It is important to note that the physical activities included in this program are similar in intensity to that of a physical education class, sport/recreational, or exercises session. For the program, all participants will have a trained volunteers at all times. All staff will have current CPR certifications and specialized training for working with individuals with disabilities. In the unlikely event of an injury, the researchers have no plans for compensation. In addition, there is a risk of a breach of confidentiality. However, all efforts will be taken to maintain confidentiality. All information collected in this study is strictly confidential, and your child's name will not be identified at any time. The data collected will be grouped with data from other subjects for presentations at scientific conferences and publication in scientific journals. Data will be stored in a locked file cabinet in a locked room and/or on a password-protected computer/iPad. Only the investigator will have access to the data. Your child's information may be shared with representatives of Auburn University and government authorities if required by law.

To reduce the risk of COVID-19, the research staff will wear full personal protective gear during data collection. This includes a face mask, gloves, face shield, and lab coat. Researchers will maintain 6 feet social distance whenever possible. In the event the researcher needs to enter the 6-foot bubble, he/she will minimize his/her time within the bubble. All participants with be tested individually to allow for proper social distancing. All equipment will be decontaminated before and after each participant and hand sanitizers will be used by research participants before touching any equipment. Participants and research staff will complete the questions outlined in the GuideSafe tool the day before and day of data collection. An additional appendix has been added to provide details about the safety considerations for COVID-19.

Are there any benefits to yourself or others? Your child's participation is completely voluntary. The study is designed to help increase participants skill levels, and physical activity. In addition, the study may have substantial impact on understanding how health-related and behavioral outcomes of these programs for individuals with and without developmental disabilities. You are free to ask questions or to withdraw from participation of your child's at any time without penalty. A signed copy of this guardian permission form will be given to you.

Will you receive compensation for participating? No compensation is provided for participants in the land-based aerobics as the program is offered free of charge.

If you change your mind about participating, you can withdraw your child at any time during the study. Your child's participation is completely voluntary. If you choose to withdraw your child, all data can be withdrawn as long as it is identifiable.   Your decision about whether or not to participate or to stop your child from participating will not jeopardize your or your child's future relations with Auburn University or the School of Kinesiology.

Your privacy will be protected. All information collected in this study is strictly confidential, and your child's name will not be identified at any time. The data collected will be grouped with data from other subjects for presentations at scientific conferences and publication in scientific journals. Data will be stored in a locked file cabinet in a locked room and/or on a password-protected computer. Only the investigator will have access to the data. Your information may be shared with representatives of Auburn University and government authorities if required by law.

If you are interested in having your child participate in new studies in the lab, your contact information will be added to a recruitment database maintained by Dr. Pangelinan and retained for up to 3 years following completion of the study. However, there will be no link between your contact information and any data collected for the study. All contact information will be stored securely on a password-protected computer.

If you have questions about this study, *please ask them now or* contact Emily Munn at eem0012@auburn.edu or Dr. Melissa Pangelinan at melissa.pangelinan@auburn.edu or by phone at 334-844-8055. A copy of this document will be given to you to keep.

Parent/Guardian's Initials ______

The Auburn University Institutional Review Board has approved this Document for use from 11/18/2020 to 04/15/2021
Protocol # 19-169 MR 1907

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COLLEGE OF EDUCATION

If you have questions about your rights as a research participant, you may contact the Auburn University Office of Human Subjects Research or the Institutional Review Board by phone (334)-844-5966 or e-mail at hsubjec@auburn.edu or IRBChair@auburn.edu.

HAVING READ THE INFORMATION PROVIDED, YOU MUST DECIDE WHETHER OR NOT YOU WISH TO HAVE YOUR CHILD PARTICIPATE IN THIS RESEARCH STUDY. YOUR SIGNATURE INDICATES YOUR WILLINGNESS TO HAVE YOUR CHILD PARTICIPATE.

____

Child's Name

____________________________________ ____________________________ ________

Parent/Guardian's Name   Parent/Guardian's Signature   Date

____________________________________ ____________________________ ________

Investigator Obtaining Consent   Investigator's Signature   Date

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Child's Name

Parent/Guardian's Name	Parent/Guardian's Signature	Date
Investigator Obtaining Consent	Investigator's Signature	Date

SCHOOL OF
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(NOTE: DO NOT SIGN THIS DOCUMENT UNLESS AN IRB APPROVAL STAMP WITH CURRENT DATES HAS BEEN APPLIED TO THIS DOCUMENT.)

MINOR/PARTICIPANT ASSENT (AGES 13-75)

for a Research Study entitled

"The Effects of Adaptive Exercise on Individuals with and without Disabilities"

You are asked to be in the study because you will do an exercise program. We want to know if this program helps make you active, sleep better, move better, and be healthy.

If you want to be in the study, you do different activities two times for about 1 hour. The first time will be before the exercise program and the second time will be after the exercise program. You will walk for 6 minutes and will wear a wrist-band that looks like a FitBit or Apple Watch. The wrist-band will measure how active you are and how your heart and lungs work. You will wear the wrist-band during the day and when you sleep. You will do a test on an iPad where you have to pay attention. You will do a balance test on a machine that measures how you move. You will do a test where you standing up from a chair, walk, turn around, and sit back down.

The exercise program will be at your day program. You will do the exercise program 20 times for 1 hour each time. A video will be taken to see how you exercise. You will wear the wrist-band while you exercise. You will wear the wrist-band during the day and when you sleep.

Participant's Initials ______

The Auburn University Institutional Review Board has approved this Document for use from 11/18/2020 to 04/15/2021 Protocol # 19-169 MR 1907

You may feel tired and your body may be sore from the exercise program and tests. You can take breaks or stop at any time. The researcher and your program's staff, will try to keep you safe from injuries.

To keep you safe from COVID-19, the researchers will wear masks, face shields, gloves, and special coats. They will try to stay 6-feet away. All of our things will be cleaned and you will use hand sanitizer before touching anything. We will ask your parent or guardian questions about if you feel sick or have been near someone who is sick.

If you have any questions about what you will do or what will happen, please ask your parents or guardian or Dr. Pangelinan now. If you have questions during the tests or want to take a break please ask us.

If you would like to be in our research study, please sign and print your name on the line below.

______________________	__________________________	_______
Child's Name	Child's Signature	Date
______________________	__________________________	_______
Parent/Guardian's Name	Parent/Guardian's Signature	Date

(Parent/Guardian must also sign Parent/Guardian Permission form!)

______________________	__________________________	_______
Investigator Obtaining Consent	Investigator's Signature	Date

Appendix B:

Pediatric Movement and Physical Activity Lab

School of Kinesiology - Auburn University

MOVEMENT. HEALTH. PERFORMANCE.

Timed Up and Go (TUG) Test

Subject ID:___________________________ Researcher: ______________________

1. Equipment: chair with arm rests, tape measure, tape, stop watch.
2. Begin the test with the subject sitting correctly (hips all of the way to the back of the seat) in a chair with arm rests. The chair should be stable and positioned such that it will not move when the subject moves from sit to stand. The subject is allowed to use the arm rests during the sit – stand and stand – sit movements.
3. Place a piece of tape or other marker on the floor 3 meters away from the chair so that it is easily seen by the subject.
4. Instructions: "On the word GO you will stand up, walk to the line on the floor, turn around and walk back to the chair and sit down. Walk at your regular pace.
5. Start timing on the word "GO" and stop timing when the subject is seated again correctly in the chair with their back resting on the back of the chair.
6. The subject wears their regular footwear, may use any gait aid that they normally use during ambulation, but may not be assisted by another person. There is no time limit. They may stop and rest (but not sit down) if they need to.
7. Normal healthy elderly individuals usually complete the task in ten seconds or less. Very frail or weak elderly with poor mobility may take 2 minutes or more.
8. The subject should be given a practice trial that is not timed before testing.
9. Results correlate with gait speed, balance, functional level, the ability to go out, and can follow change over time.

Date	Trial 1	Trial 2	Comments

APPENDIX C1

Pediatric Movement and Physical Activity Lab

School of Kinesiology - Auburn University

MOVEMENT. HEALTH. PERFORMANCE.

6-MINUTE WALKING TEST

Subject ID# ___________

Walk # ______ Tech ID: _________ Date: __________

Gender: M F Age: ____ Race: ____ Height: ___ft ____in, ____ meters

Weight: ______ lbs, _____kg

Medications taken before the test (dose and time): __________________

Lap counter: __ __ __ __ __ __ __ __ __ __ __ __ __ __ __

Measure	Baseline	End of Test
Time (minute : seconds)	:	:
Blood Pressure (sys/dia)	/	/
Heart rate (bpm)		
Dyspnea (Borg scale)		
Fatigue (Borg Scale)		
SpO2 (%)	%	%

*Stopped or paused before 6 minutes? No Yes, reason: _______________

*Other symptoms at end of exercise: angina, dizziness, hip, leg, or calf pain

Number of laps: _____(x 60 meters) + final partial lap: _____ meters =

Total distance walked in 6 minutes: ______ meters

Predicted distance: _____ meters Percent predicted: _____%

Comments: ____

Interpretation (including comparison with a pre-intervention 6MWD): ________________________

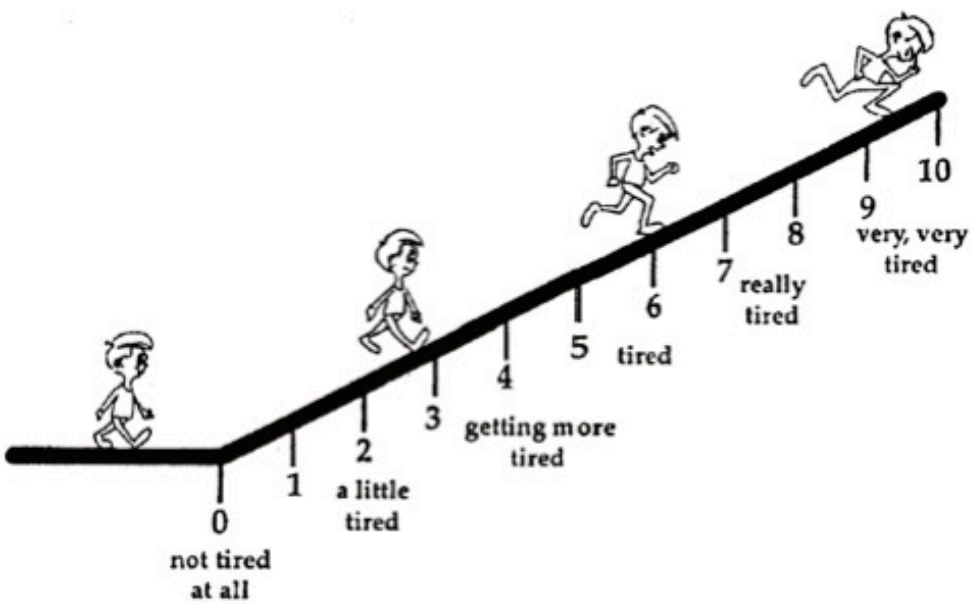
* In the unlikely event of the test stopping for a medical reason, please follow the Emergency Action Plan (Appendix D)

APPENDIX C1

Pediatric Movement and Physical Activity Lab
School of Kinesiology - Auburn University

MOVEMENT. HEALTH. PERFORMANCE.

ADAPTED BORG SCALE

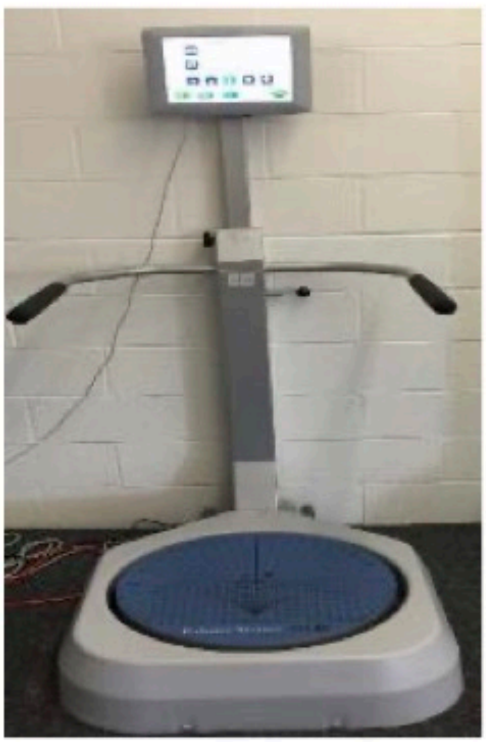


Pediatric Movement and Physical Activity Lab
School of Kinesiology - Auburn University

MOVEMENT. HEALTH. PERFORMANCE.

Biodex Balance Testing Protocol

Picture of the Biodex Balance System



Clinical Test of Sensory Integration of Balance (CTSIB) – Static Balance

SubID: ________ Test Date: ________

Foot Position (R) ___________ Foot Orientation (R) ___________

Foot Position (L) ___________ Foot Orientation (L) ___________

Task	Balance Score	Comments
1. Eyes Open Firm Surface		
2. Eyes Closed Firm Surface		
3. Eyes Open Foam Surface		
4. Eyes Closed Foam Surface		

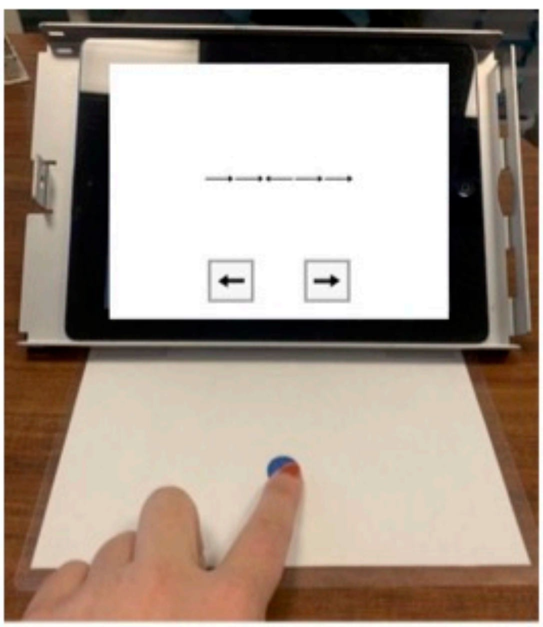
For this test, the participant will stand on the platform with his/her feet hip distance apart. The foot position and orientation is noted for each foot. The participant will then stand with his/her arms by his/her side and his/her eyes open while standing on a firm surface for 20 seconds. A researcher will stand behind the participant to ensure participant safety. The next trial the participant will stand with his/her arms by his/her side and his/her eyes closed while standing on a firm surface for 20 seconds. Again, a researcher will stand behind the participant to ensure participant safety. The last two trials are identical to the first two only he/she will stand on a foam surface with his/her eyes open or closed. The total amount of time for this test is 80 seconds for the four trials plus set-up time (~2-3 minutes total). The balance score is based on the amount of body sway measured during the trial based on the center of pressure on the platform.

Pediatric Movement and Physical Activity Lab
School of Kinesiology - Auburn University

MOVEMENT. HEALTH. PERFORMANCE.

Flanker Inhibitory Control and Attention Testing

The Flanker is administered through the NIH Toolbox application via an iPad. The iPad and NIH Toolbox application are password-protected. The participants' data will be saved using their study-specific subject identifier (e.g., ZUM001). For this task, the participant begins with his/her index finger touching the blue "home" circle (laminated paper). Five arrows are presented on the screen. The participant must touch the arrow at the bottom of the screen that matches the direction of the middle arrow as quickly and accurately as possible and then return to the home circle. This task takes 3 minutes to complete and is validated for use for individuals 3 – 85 years.



Appendix C:

Week 1 & 2	Beats Pre-Minutes
If I Can't Have You	124 BPM
Spread Love	135 BPM
Baby	130 BPM
Wild	115 BPM
Can't Stop the Feeling	113 BPM
Week 3 & 4	
I Can't Have You	124 BPM
Better When I'm Dancing	128 BPM
Wild	115 BPM
Baby	130 BPM
Spread Love	135 BPM
Can't Stop the Feeling	113 BPM
Week 5 & 6	
I Like to Move It	130 BPM
Better When I'm Dancing	128 BPM
Let's Twist Again	162 BPM
Spread Love	135 BPM
Baby	113 BPM
Can't Stop the Feeling	
Week 7 & 8	
I Like to Move It	130 BPM
Better When I'm Dancing	128 BPM
Let's Twist Again	162 BPM
I Will Survive	117 BPM
Levitating	103 BPM
Can't Stop the Feeling	113 BPM
Week 9 & 10	

There Is Nothing Holding Me Back	122 BPM
Better When I'm Dancing	128 BPM
Let's Twist Again	162 BPM
I Will Survive	117 BPM
Levitating	103 BPM
Eye Of the Tiger	109 BPM