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Changes in cognitive function after a 12-week exercise intervention in adults with Down syndrome

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ABSTRACT

Background: Between 250,000 and 400,000 individuals in the United States are diagnosed with Down syndrome (DS). Nearly all adults with DS will develop Alzheimer's disease pathology starting in their thirties. Recent studies suggest that increased physical activity (PA) may be important for maintaining components of cognition, including memory.

Objective: The purpose of this study was to evaluate changes in cognitive function after completion of a 12-week exercise intervention in adults with DS.

Methods: Participants were randomized to attend 30-minute group exercise sessions 1 or 2 times a week for 12 weeks. The exercise sessions were delivered via video conferencing on a tablet computer to groups of 5–8 participants. Sessions consisted of aerobic based exercises such as walking and jogging to music, dancing, as well as strength based exercises such as vertical jumps, bicep curls, and squats. Cognitive function was measured at baseline and end of study using the Cantab Dementia Battery for iPads, which assessed the cognitive domains of memory, attention, and reaction time.

Results: Twenty-seven participants (27.9 ± 7.1 years of age, 40.7% female) enrolled and completed the 12-week intervention. Participants randomized to 1 session/week averaged 26.6 ± 3.0 min/week of PA from the group exercise session. Participants randomized to 2 sessions/week averaged 57.7 ± 15.3 min/week of PA from the group exercise sessions. Participants improved their performance on the two memory variables ($p = 0.048$ and $p = 0.069$).

Conclusion: Increased exercise may have positive changes on memory and other cognitive functions.

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Introduction

Nearly all adults with Down Syndrome (DS) will develop Alzheimer's disease (AD) pathology starting in their thirties. Based on a current lifespan of 55–60 years, approximately 70% will develop AD, a number that will grow with increased life expectancy.¹ It is difficult to identify early signs of AD related dementia in adults with

DS. However, deficits in cognitive control and features of fronto-temporal dementia are thought to be early indicators of dementia in this group.^{2–6} Previous research has identified that increased physical activity (PA), may limit declines, or improve cognitive control in individuals with early dementia, thus improving quality of life.⁶

Recent studies suggest that increased PA may be important for maintaining components of cognition, including attention, memory, and executive control, in patients with AD^{7–16} For example, Ruscheweyh et al.¹⁷ conducted a six-month intervention where 62 healthy older adults were randomized to a moderate intensity PA intervention (nordic walking), low-intensity PA intervention (gymnastics) or a control group. The two exercise intervention groups met for 50 min 3/week across the 6-month study. Results found that memory scores improved in both the low and moderate

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intensity intervention groups, but not the control group.

Similarly, research has also shown that PA may improve cognitive function in adults with DS,^{18–21} who are at risk for AD. For example, Chen et al.¹⁹ conducted a study in 20 adults with DS in which 10 adults walked one time on a treadmill for 20 min at moderate intensity, and the other 10 watched a video. There was significant improvement in inhibition ($p = 0.03$) in the adults with DS who completed the single bout of moderate activity compared to those who watched the video. Similarly, Pastula and colleagues¹⁹ completed an 8-week moderate intensity exercise-training program in 14 young adults with DS. Participants completed ~30 min moderate-intensity circuit-training workouts 3 times a week. The intervention resulted in a significant improvement in aerobic fitness ($p < 0.002$) and perceptual and mental speed ($p < 0.002$). Together, these findings suggest that participation in moderate intensity exercise may produce improvements in cognition in individuals with DS. However, additional research is needed.

A recently completed trial examining the feasibility of group exercise session delivered remotely to young adults with DS, across 12-weeks afforded us the opportunity to conduct a secondary analysis to evaluate changes in cognitive function in adults with DS who attended 30-minute group exercise session either one or two times per week. Therefore, the purpose of this study was to evaluate the influence of a 12-week moderate PA program on changes in cognitive function in adults with DS without dementia.

Methods

Overview of study design

Adults with DS participated in a 12-week, at home, group exercise program delivered by video conferencing (Zoom Inc., San Jose, CA) on an iPad mini tablet computer (Apple Inc., Cupertino, CA). This study took place in the (Blinded for Review) metropolitan area from December 2015–July 2016. Participants were randomized to receive the group activity sessions for 30 min, either once or twice per week to determine the optimal dosage of weekly sessions needed to see changes in cognitive function. To examine changes in cognitive function, a battery of cognitive tests was assessed pre- and post-intervention. A detailed method, attendance to group sessions, and PA obtained in the sessions has previously been reported (citation blinded For Review). This study was approved by the Human Subjects Committee at the (Blinded For Review).

Participants

Participants were men and women, 18–35 years of age with a diagnosis of Down syndrome, as verified by their primary care physician. Participants over the age of 35 were excluded as they may have already begun to develop dementia. Additional inclusion criteria included: 1) Functional ability sufficient to understand directions, ability to communicate through spoken language, 2) Reside in a supported living condition either at home or with no more than 1–4 residents and have a caregiver. 3) Wireless Internet access in the home. 4) Ability to participate in PA verified by physician consent. Participant exclusion criteria included: 1) Currently pregnant, planning on becoming pregnant during the study. 2) Participation in a regular exercise program, defined as greater than 500 kcal/wk. of planned activity as estimated by questionnaire.²²

Recruitment procedures

Participants were recruited through local community programs serving adults DS and with print and web advertisements in the

target area. Home visits were scheduled with potential participants and their legal guardian (if applicable) to obtain written consent or legal guardian consent and participant assent. Participants were randomized by computer into either the once a week group or twice a week group with equal allocation between groups.

Intervention

Thirty-minute sessions were delivered via video conferencing either one or two times per week over 12 weeks to groups of 5–8 participants, each in their own home. Group video conferencing was chosen as this approach requires no travel commitment from care providers or parents, and offers the potential for peer support and socialization. Additional details regarding the rationale for this approach have been previously published.²³

A health educator, who was a specialist in adapted physical education and experienced in working with adults with DS, led the exercise sessions. The 1 session/week and 2 sessions/week groups were conducted separately but led by the same health educator. Sessions consisted of a 5-minute warm-up, 20 min of moderate to vigorous intensity PA (i.e., 3–6 METs), and a 5-minute cool-down period. Exercise intensity increased progressively across the first 6 weeks of the intervention and then remained steady weeks 7–12.

Outcomes

The intensity and duration of all group exercise sessions were assessed with a Fitbit monitor worn on the non-dominant wrist during all group exercise sessions.

Cognitive function was assessed using the Cantab Dementia Battery for iPad at baseline and 12-weeks. This battery assesses all cognitive domains including: processing speed, psychomotor speed, sustained attention, visual episodic memory, working memory, and cognitive control. In addition to numerous AD specific trials,^{24,25} this battery has also been used in several DS trials.^{26,27} The specific cognitive tests administered were the attention switching task, paired associates learning, and reaction time.

Attention Switching Task (AST) is a measure of attention and cognitive flexibility. For this task, the test displayed an arrow which could appear on either side of the screen and point in either direction. Each trial displayed a cue at the top of the screen that indicated to the participant whether they had to select the right or left button according to the “side on which the arrow appeared” or the “direction in which the arrow was pointing”. Some trials displayed congruent stimuli (e.g. arrow on the right side pointing to the right) whereas other trials display incongruent stimuli “switching”, which requires a higher cognitive demand (e.g. arrow on the right side of the screen pointing to the left). Two AST measurements were collected. AST 1 measured the median latency of response (from stimulus appearance to button press) in assessed block(s) in which the rule is switching. Higher scores indicate worse performance. AST 2 measured the median latency of response (from stimulus appearance to button press) on congruent trials. Higher scores indicate worse performance.

Paired Associates Learning (PAL) assesses visual memory and new learning. For this task boxes were displayed on the screen and were “opened” in a randomized order. One or more of them contained a pattern. The patterns were then displayed in the middle of the screen, one at a time and the participant had to select the box in which the pattern was originally located. If the participant made an error, the boxes were opened in sequence again to remind the participant of the locations of the patterns. Two PAL measurements were collected. PAL 1 assessed is the number of times the subject chose the incorrect box for a stimulus on assessment problems. Higher scores indicate worse performance. PAL 2 measured the

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