Effect of Moderate-Intensity Exercise Training on the Cognitive Function of Young Adults with Intellectual Disabilities

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Abstract

Pastula RM, Stopka CB, Delisle AT, and Hass CJ. Effect of moderate-intensity exercise training on the cognitive function of young adults with intellectual disabilities. *J Strength Cond Res* 26(12): 3441–3448, 2012—In addition to cognitive impairment, young adults with intellectual disabilities (IDs) are also more likely to be in poor health. Exercise may help ameliorate both of these deficits. While the health benefits of exercise are well documented and understood, the cognitive benefits of exercise are emerging. Exercise has been shown to improve the cognitive function of young, old, and diseased populations but few studies have evaluated the effect of exercise training on the cognitive functioning of individuals with IDs. The purpose of this study was to determine the effect of moderate-intensity exercise training on the cognitive function of young adults with IDs. Fourteen students (age, 19.4 ± 1.3 years) with mild to moderate IDs participated in an 8-week comprehensive exercise intervention program based on circuit training, aerobic dancing, and adapted sport activities. Sessions lasted 45 minutes, and intensity was maintained at 60–70% of maximum heart rate (HR_{max}). Aerobic fitness was assessed via the Young Men's Christian Association (YMCA) step test, and intellectual functioning was assessed via 3 subtests from the Woodcock-Johnson III Tests of Cognitive Abilities once before and after the intervention. Performance was significantly improved on all 3 cognitive tests (all, $p < 0.002$). Aerobic fitness also significantly improved ($p < 0.002$). The mean percent increase in processing speed, a measure taking into account each individual's performance on the 3 subtests, was 103%. The mean individual improvement in aerobic fitness was 17.5%. Moderate-intensity exercise training can yield robust improvements in the cognitive functioning and aerobic fitness of young adults with IDs. These effects support the inclusion of exercise into the lives of young adults with ID to promote their physical and cognitive health. Fourteen students (age, 19.4 ± 1.3 years) with mild to moderate IDs participated in an 8-week comprehensive exercise intervention program based on circuit training, aerobic dancing, and adapted sport activities. Sessions lasted 45 minutes and intensity Powered by Editorial Manager and Preprint Manager from Aries Systems Corporation was maintained at 60–70% of HR_{max}. Aerobic fitness was assessed via the YMCA step test, and intellectual functioning was assessed via 3 subtests from the Woodcock-Johnson III Tests of Cognitive Abilities once before and after the intervention. Performance was significantly improved on all 3 cognitive tests (all, $p < 0.002$). Aerobic fitness also significantly improved ($p < 0.002$). The mean percent increase in processing speed, a measure taking into account each individual's performance on the 3 subtests, was 103%. The mean individual improvement in aerobic fitness was 17.5%. Moderate-intensity exercise training can yield robust improvements in the cognitive functioning and aerobic fitness of young adults with IDs. These effects support the inclusion of exercise into the lives of young adults with ID to promote their physical and cognitive health.

Key Words physical fitness, development disabilities, exercise-induced neuroplasticity, cognitive plasticity

Introduction

Intellectual disability (ID) is the most prevalent of all developmental disabilities. An ID is a disability characterized by significant limitations both in cognitive functioning and in adaptive behavior, which covers conceptual, social, and practical skills (1,23). In addition to intellectual impairment, when compared with their typically developed peers, persons with ID are more likely to be obese, less likely to be physically active, and are twice as likely to develop a chronic disease (4,15,25,26,38). One intervention that may be efficacious in ameliorating these deficits is aerobic exercise. While the cardiovascular and overall health benefits of aerobic exercise are well established (3,8,16,18,29,37), the positive effects of aerobic exercise on

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cognitive functioning is emerging. Indeed, aerobic exercise has been shown to significantly improve cognitive function in healthy, young, aged, and diseased populations (7,13,14,20). However, it is unclear if aerobic exercise training can improve cognitive function in young adults with IDs. Many young adults with ID desire independence but their poor health and cognitive impairment remain a hindrance to their success. Early instilment of a physically active lifestyle may catalyze their social, mental, and physical development and may set a trajectory of healthy behavior to be maintained well into adulthood. A physically active lifestyle has the potential to greatly benefit individuals with ID at this transitory point in their lifespan.

Previous studies evaluating the effect of exercise training on the cognition of persons with ID have produced mixed results. Early studies concluded that the exercise can produce significant improvements in the intellectual functioning and behavioral characteristics of young adult men with ID (6,9,24). Contrastingly, more studies concluded that exercise had little effect on the cognitive functioning of adolescents and young adults with IDs (39,40). This finding is surprising because numerous studies have documented a strong positive correlation between increased fitness level and improved cognitive performance in typically developed children, young adults, and older adults (7,14). One potential explanation for these conflicting findings is differences in the exercise interventions delivered.

Specifically, several meta-analyses have reported that chronic moderate-intensity aerobic exercise of modest duration (30–60 minutes) may best improve cognitive function in humans (7,13,14,21). A large body of evidence suggests that the effects of exercise training on cognition are mediated by the actions of neurotrophic factors (10). However, the transcription of these neurotrophic factors can be attenuated during overtly physically demanding exercise (22,34). This biochemical impairment suggests that exercise need not be vigorous in nature to elicit improvement in cognitive function. However, no study has evaluated the effect of a strictly moderate-intensity aerobic exercise training regimen on the cognitive function of young adults with IDs. Therefore, the purpose of this study was to evaluate the effect of moderate-intensity aerobic exercise training on the cognitive function of young adults with IDs. We hypothesized that a moderate dose of exercise is sufficient to produce a substantial improvement in both the cardiovascular fitness and cognitive function of young adults with IDs.

Methods

Experimental Approach to the Problem

We adopted a quasi-experimental design (before and after) to achieve our purpose. Adolescents with IDs were tested before and after an 8-week exercise intervention. The intervention combined resistance training and aerobic exercise that maintained heart rate (HR) within a moderate-intensity level [60–70% of maximum heart rate (HR_{max})] for the duration of the exercise session. Because exercise within this intensity range has been shown to improve cognitive function, we speculated that our intervention could improve cognitive faculties in these adolescents.

To assess cognitive abilities, we used validated tests of processing speed for this population. Processing speed is subserved by brain areas shown to be amenable to exercise interventions. Furthermore, to assess the fitness improvements associated with our intervention, we performed the Young Men's Christian Association (YMCA) step test.

Subjects

Sixteen volunteers (age, 19.4 ± 1.3 years; height, 1.64 ± 0.1 m; mass, 77.59 ± 15.8 kg; 9 men and 5 women) from a school serving children with IDs in North Central Florida participated in this study. The participants volunteered for the study with approval from their parents/legal guardians, teachers, and physicians. Participants, or legal guardian where appropriate, provided written informed consent to participate approved by the university's institutional review board. The participants had mild to moderate degrees of ID and various forms of ID, including the following confirmed diagnoses: Down's syndrome, Prader-Willi syndrome, and autism spectrum disorders. Some of the participants had secondary conditions such as mild cerebral palsy, but they were able to communicate (either verbally or through American Sign Language), were ambulatory, and were capable of performing all of the exercises. None of the participants had participated in physical training for at least 5 months before the start of this study. However, 11 of the 16 volunteers had previously participated in an organized exercise program at the University of Florida. These programs were similar to the nature of the program used in this study. The students who were exposed to this type of program for the first time are identified in Table 1.

Procedure

Cognitive functioning was assessed via 3 subtests from the Woodcock-Johnson III Tests of Cognitive Abilities (WJ III COG) at baseline and after 8 weeks of moderate-intensity exercise training. The selected test battery included the visual matching (Test 6B), decision speed (Test 16), and pair cancellation (Test 20) subtests. Together, these 3 tests provide information about the broad cognitive ability of processing speed (41). Processing speed refers to the ability to perform automatic cognitive tasks that require sustained attention. Independently, the visual matching subtest measures perceptual speed and cognitive fluency as the individual makes visual symbol discriminations. The decision speed subtest evaluates cognitive efficiency as the speed of processing simple concepts is assessed. The pair cancellation subtest independently measures executive processing and sustained attention/concentration, providing information about an individual's interference control and ability to stay vigilantly focused on a particular task. Practice effects are common challenges for the conduct of studies evaluating cognitive performance. Furthermore, many tests of cognitive function

TABLE 1. Full-body circuit training workout.*

Exercise	Intensity	Duration	Rest time
Circuit 1			
Air squat	120–140 $b \cdot min^{-1}$	1 Minute	5-Second transfer time
Squat jumps	120–140 $b \cdot min^{-1}$	1 Minute	5-Second transfer time
Front lunge right leg	120–140 $b \cdot min^{-1}$	1 Minute	5-Second transfer time
Front lunge left leg	120–140 $b \cdot min^{-1}$	1 Minute	5-Second transfer time
Circuit 2			
Full range ACSM push up	120–140 $b \cdot min^{-1}$	1 Minute	5-Second transfer time
Flip grip tricep kickback	120–140 $b \cdot min^{-1}$	1 Minute	5-Second transfer time
Dumbbell Y press	120–140 $b \cdot min^{-1}$	1 Minute	5-Second transfer time
Dumbbell front raise	120–140 $b \cdot min^{-1}$	1 Minute	1-Minute rest
Circuit 3			
Straight sit ups	120–140 $b \cdot min^{-1}$	1 Minute	5-Second transfer time
V-ups	120–140 $b \cdot min^{-1}$	1 Minute	5-Second transfer time
Power sit up	120–140 $b \cdot min^{-1}$	1 Minute	5-Second transfer time
Flutter kicks	120–140 $b \cdot min^{-1}$	1 Minute	1-Minute rest
Circuit 4			
Full supination concentration curl	120–140 $b \cdot min^{-1}$	1 Minute	5-Second transfer time
Bent over dumbbell row	120–140 $b \cdot min^{-1}$	1 Minute	5-Second transfer time
Rotating curls	120–140 $b \cdot min^{-1}$	1 Minute	5-Second transfer time
Back fly	120–140 $b \cdot min^{-1}$	1 Minute	1-Minute rest

*Total time: 20-minute workout.

are not designed and validated to be used in repeated-measure design studies. We chose the WJ III COG because it is unique in which the presented norms are based on data collected continuously, throughout the school year. This makes the WJ III COG an ideal testing battery for assessing cognitive growth in a student population and particularly useful for assessing a change in performance after an intervention of a specific time interval. The test-retest reliability coefficients for the visual matching, decision speed, and pair cancellation tests, respectively, are 0.76, 0.73, and 0.78. The reliability coefficient of the processing speed cluster, made up of these 3 subtests, is 0.92.

After standardized and validated testing procedures, each student was given 3 minutes to complete each subtest. The primary focus of these tests was to assess cognitive ability, and so in cases where a test taker's physical attribute hindered them from proceeding with a test, appropriate testing accommodations were made. For instance, if a test taker struggled with fine-motor control and spent an abundance of time circling their answers in the practice trials, they were asked to point to their answers during the timed test and their choices were circled by the administrator. The raw scores and the time taken for each subtest (if completed in less than 3 minutes) were recorded and translated into standard score (SS) by the *WJ COG III Compuscore and Profiles Program.* SS take the test taker's raw score and gender and age norms into account and scaled the same as most deviation intelligence quotient (IQ) scales: 131 and above = very superior, 121–130 = superior, 111–120 = high average, 90–110 = average, 80–89 = low average, 70–79 = low, and 69 and below = very low.

Each computed SS is, by default, accompanied with a 68% confidence band, which is a range of SS extending from 1 standard error of the measurement (SEM) below the test taker's obtained score to 1 SEM above the test taker's obtained score. Two times out of three repeated attempts, a subject will score within this range and the range will be representative of their "true" ability. If the provided bands from 2 repeated tests overlap at all, there is no difference in cognitive ability. However, a separation between the ends of two test bands is indicative of a "possible difference" in cognitive ability. Further, a separation between the two tests bands that is greater than the width of the wider band is indicative of a "real difference" in cognitive ability. The tests were administered by a trained investigator under the supervision of a licensed psychologist.

Aerobic fitness was assessed via the YMCA step test. This test was administered in accordance with published guidelines (17). Each student was asked to step up (right foot up then left foot up) and then down (right foot down then left foot down) from a platform that was raised 12 inches off the ground. The subject continued this stepping motion at a quick but comfortable pace for 3 minutes. After 3 minutes, the subject was asked to sit down, and their pulse was counted at the radial artery for 1 minute. This count was recorded as their recovery heart rate (RHR).

A comprehensive intervention incorporating a wide variety of moderate-intensity aerobic activities was delivered 3 times a week over an 8-week period; each session lasted 45–60 minutes and occurred from 1 to 2 PM at the same time of day after their lunch period. All participation days (testing and training) were very structured; the participants worked out after their prearranged controlled school lunch (which occurred after their morning of largely sedentary vocational activities). During the intervention, the students were supervised by trained exercise facilitators, wherein the prescribed exercise intensity was 60–70% of HR_{max} because this HR range is classified as moderate-intensity exercise (2). HR_{max} was identified using the percentage of HR_{max} method; each participant's age was subtracted from 220 to provide an estimate of their HR_{max} (19). Heart rate was monitored with Polar FT2 HR monitors; these monitors sounded when exercising HR was outside of the prescribed range. Periodic 15-second counts of pulse via palpation at the radial artery were used to confirm the accuracy of the HR monitors.

During the first 20 minutes of each exercise session, participants performed a total body circuit training workout. Each circuit was composed of 4 exercises, and 4 circuits composed the full body circuit training workout. Exercises in the first circuit provided a lower-body workout. The second "push-"oriented circuit focused on the upper body. The third circuit focused on providing a core workout. Last, participants performed a "pull-"oriented upper-body workout. An example circuit training workout is provided by Table 1. Each exercise of each circuit was performed for a duration of 1 minute. Intensity was altered by changing tempo or load, as long as HRs remained within the prescribed range. The amount of rest in between exercises and circuits was also dependent on the participants' working HRs (e.g., longer periods of rest if their HRs were higher than the prescribed target heart rate [THR] or shorter periods of rest if their HRs were on the lower end of the prescribed THR). Because the participants exercised in their own groups, with their exercise facilitators, their rest periods could be appropriately tailored to them and their level of fitness. However, in general, there was no resting in between completing exercises of the same circuit, just a 5-second transfer time for repositioning. Also, there was typically a 1-minute rest period in between circuits. Exercises were changed every 2 weeks, and intensity (load or tempo) was increased every 2 weeks if the individual could maintain their HR in the target range. When teaching proper exercise form, the exercise facilitators provided both visual and verbal exercise cues to improve the reproduction of the modeled movement pattern. Exercise facilitators always performed the exercise with the participant, so the participant could model the behavior. If needed, the instructional cues were modified. For instance, if the exercise at hand were an air squat, an exercise facilitator would demonstrate the exercise while explaining what they are doing with concise statements. Verbal cues for teaching an air squat may include "sit in a chair" then, "drive up through your heels!" If a participant struggled with retaining good posture, a facilitator would cue proper movement by saying, "chin up," "chest out," or "butt out." If a movement such as an air squat could not be performed within a reasonable number of attempts, with cueing, a movement pattern engaging similar muscle groups would substitute. For example, rather than performing a technically sound air squat, an exercise facilitator may crouch to the ground, stick both hands out with fully supinated forearms, and ask for a "low five," cueing the participant to slap the open hands of the facilitator. After the participant crouched down for the "low five," the facilitators would pop-up to a standing position and encourage the participant to give them a "high five." Furthermore, if a participant was not responding or having a bad day, a quiet declaration of how a classmate rival was doing would often result in a personal best performance.

The next 30–45 minutes of exercise would be devoted to aerobic sport activity. These sport activities included: "noodle soccer" (where foam pool noodles were used to propel light weight 'grocery store' plastic balls into goals), multi-pitcher/base kickball and tee-ball, dance marathons, volleyball, relay races that required multiple motor skills (e.g., lunging across the basketball court followed by the kicking or punching of a martial arts sparring bag) stadium step,

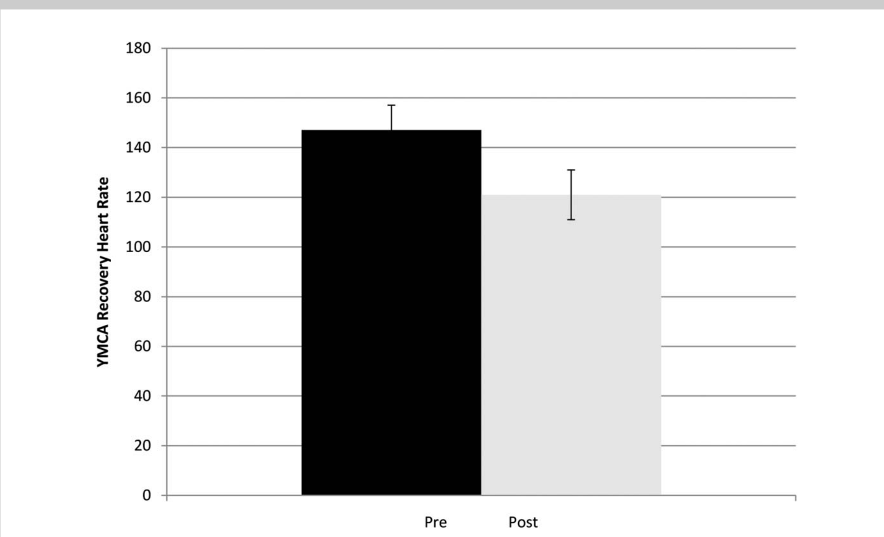

Figure 1. Recovery heart rates for the YMCA step test recorded before and after the intervention.

Table 2. Cognitive performance.

Participant	Visual matching (pretest)	Visual matching (posttest)	Decision speed (pretest)	Decision speed (posttest)	Pair cancellation (pretest)	Pair cancellation (posttest)	Processing speed (pretest)	Processing speed (posttest)
A	1 (1–1)	6	6 (1–12)	26	41 (39–44)	48	1 (1–1)	13*
B	48 (43–52)	69	58 (53–62)	72	77 (75–79)	79	52 (48–55)	70*
C	4 (1–7)	24	10 (4–15)	44	44 (42–47)	55	4 (1–7)	31*
D	56 (51–60)	60	60 (55–65)	77	64 (62–67)	74	57 (54–60)	67*
E†	1 (1–5)	23	18 (13–23)	32	48 (46–51)	52	7 (4–10)	26*
F†	1 (1–3)	1	1 (1–7)	8	29 (23–34)	45	1 (1–1)	1
G	1 (1–1)	1	8 (3–14)	9	46 (44–49)	49	1 (1–1)	1
H	27 (23–31)	39	65 (60–70)	65	48 (45–50)	67	41 (38–45)	48‡
I†	33 (29–37)	42	28 (23–33)	56	59 (57–61)	63	26 (23–29)	45
J	12 (9–16)	21	26 (21–30)	34	46 (43–48)	47	17 (14–20)	26*
K	19 (15–22)	30	35 (30–39)	46	48 (45–50)	47	24 (22–27)	35*
L	23 (20–27)	28	28 (24–33)	47	56 (53–58)	55	23 (20–26)	34*
M	1 (1–2)	1	4 (1–13)	9	35 (32–39)	40	1 (1–2)	1
N	39 (35–43)	39	60 (55–65)	58	58 (56–60)	68	47 (44–51)	47
Mean	19	27.4§	29.1	41.6§	49.9	56.4§	21.5	31.8§
SD	19.2	21.3	23.1	23.0	12.2	11.9	20.6	22.6

*Real difference in the cognitive ability as per the guidelines of the WJ III COG Examiner's Manual and a separation between the confidence bands of the pre- and posttest SS.
†Student who had not previously participated in a supervised exercise program at the University of Florida.
‡Possible difference in cognitive ability as per the guidelines of the WJ III COG Examiner's Manual and a separation between the confidence bands (indicated by parentheses of the pre- and posttests SS).
§Significant difference between mean prescores and postscores.

and spiral-ramp workouts (lunges, skipping, and high-knees up and down the stadium's spiral ramps), basketball games (half-court, full-court, or adapted with unique rules), and Special Olympics training (practicing their upcoming events such as dashes, throws, and broad jumps). Adapted activity organization and multiple stations per exercise session required the participants to be in a constant state of motion; lines were minimal or nonexistent for each of the above activities, so that HR remained in the target range. Each student participated in their particular sport activity with their peers and their group of exercise facilitators.

Statistical Analyses

The dependent variables of interest including test scores on the cognitive tests and step test were assessed using dependent *t*-tests. An a priori alpha level of $p \leq 0.05$ was used for determination of statistical significance.

Results

After pretesting and before the start of the intervention, 2 participants were excluded from the study because of the problematic behavior at school; the remaining 14 participants completed the entire 8-week exercise program along with pre- and posttesting. Throughout the training period, there were no reports of pain, injury, and muscle soreness, and adherence was 100%. All individuals as well as the group mean exercise HR during the intervention was 138 $b \cdot min^{-1}$ (68% average HR_{max}), confirming the participants worked within the range of 60–70% of their predicted HR_{max}. A 17.5% increase in aerobic fitness ($p < 0.002$) was observed from baseline to posttesting (Figure 1). Concurrent with the improved fitness was an observed significant improvement in all 3 tests of cognitive function (all, $p < 0.002$) and the combined measure of processing speed ($p < 0.001$). Individual and group performance on all 3 subtests can be found in Table 2.

Discussion

The results of this study suggest that exercise training at 60–70% of HR_{max} can effectively improve the cognitive function of young adults with IDs. Ultimately, the average individual increases in SS for the visual processing, decision speed, and pair cancellation subtests was 248, 133, and 15%, respectively. The average individual increase in SS for processing speed, a measure taking into account the test taker's performance on all 3 subtests, was 103%. It is important to note that these improvements in both cognitive function and aerobic fitness were elicited by a moderate dose of exercise because individuals are more likely to adopt and maintain physical activity habits when they are introduced to a program of low to moderate intensity (32,33). In fact, many of the participants of this study considered these exercise sessions to be the highlight of their week, which is reflected in the observed 100% adherence rate.

Our observations that moderate-intensity exercise training improves cognitive functioning of young adults with IDs helps to explain the conflicting findings from previous studies examining the effect of exercise training on the cognitive function of individuals with IDs. Initial studies reported that training produced a significant improvement in IQ tests that was not observed in nonintervention control or attention control groups. These improvements ranged from mean increases of 4.26–10 IQ points. These interventions were 4–10 weeks long, and the imposed exercise programs varied substantially. The first of these studies (24) was characterized by 2 hours and 40 minutes of remedial and recreational exercise that was interspersed throughout the daily school schedule (10–75 minute bouts of exercise). Corder (9), who reported the largest improvement on intelligence tests, administered 1-hour sessions of running, relays, and calisthenics 5 days per week. Alternatively, isometric strength training led to a mean gain of 8.3 IQ points (6). In contrast, the studies of Tomporowski and Elllis (39,40) have reported that exercise training does not significantly affect the cognitive function of individuals with IDs. It is important to note that the exercise sessions characterizing the interventions of Tomporowski et al. were markedly more physically demanding and longer in duration than the preceding studies that reported improvements on intelligence tests. In addition, the participants of the studies of Tomporowski et al. were much older than the participants of the studies that reported an apparent effect of exercise on cognitive function. Although we did not measure IQ, we observed robust improvements in cognitive functioning that are comparable to what was reported by the earlier studies above.

Additional research is needed to understand the physiological mechanisms underlying this exercise-cognition phenomenon. However, neuronal connections in the brain are altered during learning and memory formation, and previous research suggests that exercise facilitates the alteration of these connections (10,27). Therefore, cognitive functioning of the participants of this study is likely improved by exercise-induced neuroplasticity. Brain-derived neurotrophic factor (BDNF) is thought to be a key mediator of exercised-induced neuroplasticity (10), and in both human and animal models, exercise of low to moderate intensity is sufficient to produce a large upregulation of BDNF (22,31). In fact, more modest doses of exercise may induce neuroplasticity to a greater degree than high-intensity exercise. During high-intensity or long duration exercise (30), cortisol is released to stimulate the catabolism of stored energy sources. However, cortisol may also severely stunt the production of BDNF at the transcription level (10,22,34), hindering exercise-induced neuroplasticity. In addition to collecting cognitive function data, future studies should consider measuring the peripheral levels of BDNF and cortisol after acute and chronic bouts of exercise of various intensity and duration.

In lieu of our promising results, these findings should be interpreted with caution because of several limitations that characterized this pilot study. Because of the narrowed scope, we were unable to include an attention control group to account for the positive affects of increased attention and association. Hereby, one may argue that in an intervention study such as this, improvements in cognitive function may be a result of the Hawthorne effect. The increased attention did likely contribute to some of the observed improvements, but we do not believe that this alone could yield such a substantial improvement in cognitive function. While well-controlled studies have been conducted in the past and have shown that exercise improves cognition more than increased attention alone, data from an attention control group would have greatly strengthened the case being presented by this study. In addition, while the SS of this test are accompanied by 68% BANDS that give an idea of the test-retest reliability of this battery, the inclusion of a nonintervention control group would give a better idea of what sort of improvement is associated with repeat testing in young adults with IDs. In addition, the YMCA step test was administered because it was a quick and easy way to measure aerobic fitness, but the administration of a criterion measure test or one that could give an estimate of maximum oxygen consumption would be preferred.

Young adults with ID are considered to be in a transitionary time in their lives since they are graduating high school and will be attempting to gain employment and independence in their near future. Young adults with ID are less likely to gain employment than their peers without ID (4,11). Common types of employment which young adults with ID acquire frequently involve physical labor and repetitive tasks such as stocking shelves or bagging groceries (12). Participating in moderate-intensity exercise can help them gain the physical fitness and cognitive functioning needed for these types of jobs. Our results showed that moderate-intensity exercise improves RHR, which is an indicator for the type of physical fitness needed to perform manual labor. The cognitive tests that our participants showed improvements on were based on their speed in pairing similar objects together. Improvements in this aspect of cognitive functioning may be very useful in acquiring and maintaining jobs where they have to stock materials or bag items together that are similar while separating those that are not. Therefore, improving physical fitness and cognitive functioning simultaneously is critical for acquiring employment in young adults with ID, which in turn increases their independence, improves their quality of life, improves health outcomes (people who are employed tend to live longer and healthier than those who are unemployed), and enhances their ability to perform activities of daily living (5).

Practical Applications

Previous studies investigating the effects of exercise on cognitive abilities in individuals with ID's have produced inconclusive findings. Thus, exercise training has not been systematically recommended for this population. The individuals of this study exercised at a moderate intensity and were able to reap significant benefits in cognition. It is clear that exercise is beneficial for both physical and mental health, but the greatest challenge with youth with disabilities is finding ways for them to enjoy and adhere to a physically active lifestyle (28). While the participants in this study could either stay in their classrooms or choose to attend the exercise sessions, we observed a 100% adherence rate. This is likely because of the moderate intensity and enjoyable nature of our group exercise intervention.

While we recommend a whole-body intervention of moderate-intensity exercise for improving cognitive performance, future studies should evaluate the dose-response relationship of this exercise-cognition phenomenon. Ultimately, dose-response studies may lead to the development of an effective exercise therapy that may dismiss the presumed permanence of IDs. Increasingly, persons with IDs are searching for independence, but low graduation and employment rates remain a hindrance to their success. An effective exercise therapy may catalyze their integration into society (35,36,38) while also significantly lowering their health care costs.

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