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ADAPTIVE PHYSICAL ACTIVITY

The Cognitive Effect of a Unified Flag Football Program in Young Adults With Intellectual Disabilities: The Exploratory Study

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Abstract

This study investigated the cognitive effect of a unified flag football program in young adults with intellectual disabilities (ID). Twelve participants practiced football drills with their typical peers for 50 min each session, twice a week for 15 weeks. Measures of three aspects of executive functions (e.g., verbal working memory, measured as digit span task; cognitive planning proficiency, measured as Tower of London task; and response inhibition, measured as Stroop color and word task) were tested before and after the program. Although the benefits in the digit span and Stroop tasks were not seen, participants with ID significantly improved performance in the Tower of London task. The cognitive benefits in executive function from this unified sport program were still evident. Our preliminary findings encourage individuals with ID to attend sport programs for mental health. In future studies, large

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sample size and additional supporting measures should be included to generalize the findings to the general population with ID.

Intellectual disability (ID) is the most common neurodevelopmental disorder in human society. Approximately 6.5 million people in the United States have an ID. Further, individuals with ID are recognized as having limitations in cognitive functioning that have been closely associated with communication, social, physical, and self-care skills (Chapman & Hesketh, 2001; Chen et al., 2014). Today, various medication and alternative psychotherapeutic treatments are being used in individuals with ID; however, the considerable financial expense is always a primary issue for families with children with ID (Lunsky et al., 2019). Moreover, people with ID now live longer than previously expected, and more and more individuals live beyond their late 50s (Bittles et al., 2002; Massey & McDermott, 1995). The aging of people with mild ID appears to be equal to that of the general population (Patja et al., 2000). Therefore, it poses a new challenge to health care professionals and families with children ID to find a rehabilitative intervention to promote quality of life in individuals with ID.

Cognitive functioning is a multidimensional model that encompasses a set of mental processes, which regulate goal-directed behavior in daily life, whereas some studies indicate that individuals with ID have poorer cognitive abilities compared to their peers. In addition to lower general intelligence, individuals with ID demonstrate difficulties with speed processing (e.g., slower reaction time and shorter attention span) and working memory capacities (e.g., encoding) in response to different tasks of executive functions (EF) as compared with their typical peers (Brunamonti et al., 2011; Danielsson et al., 2010). Children with ID who demonstrate low EF—measured as cognitive planning by the Tower of London (TOL) task—have low locomotor skill (Hartman et al., 2010). Moreover, children with ID who have better object-control participate more in organized sports than those who have less object-control (Westendorp et al., 2011). Both studies support the idea that EF may be one of the critical causes of motor impairment associated with infrequent physical activity levels in individuals with ID. Thus, any intervention that stimulates neural activity may delay cognitive decline and maintain the quality of life in individuals with ID. Aerobic

exercise is an effective nonpharmacological intervention that stimulates the neural connections for cognitive improvement in older adults with cognitive impairment (Gates et al., 2013; Öhman et al., 2014) and might support the assumption that physical activity also promotes EF in individuals with ID.

As early as 1950, researchers started to investigate whether exercise intervention was able to improve cognitive function in persons with ID (Corder, 1966; Leighton et al., 1966; Oliver, 1958; Rarick et al., 1976; Tomporowski & Ellis, 1984, 1985). Tomporowski and Ellis (1984) completed a study in which adults with profound ID performed a 7-month exercise intervention, such as running, jogging, calisthenics, and circuit training, for 3 hr/day, 5 days/week, and the exercise comprised a diversity of physical activities. Still, no changes were found in their IQ scores, which were assessed on the Standford-Binet Intelligence Scale. Next year, Tomporowski and Ellis (1985) assumed the intensity of exercise level might be crucial to achievement of significant improvement. They conducted another 9-month exercise intervention with vigorous aerobic exercise, but, still, no changes in IQ were evident. Vogt et al. (2012) further found no changes (i.e., accuracy and processing speed) in EF tasks, measured as visual recognition and reaction time tasks, in adults with ID following a 30-min moderate running exercise. However, Chen et al. (2019) found young adults with ID could improve their response accuracy in the Eriksen Flanker task after a 15-week soccer program. Therefore, more studies need to investigate the connection between EF and physical activity in individuals with ID.

In summary, this study aimed to clarify the effects of a sport program on EF in young adults with ID. The unified flag football was adopted because it is one of the fastest-growing sports in Special Olympics for individuals with ID. Verbal working memory (i.e., the ability to maintain and manipulate information over short periods; Baddeley & Hitch, 1994) was measured as digit span task, cognitive planning (i.e., the ability to organize and select the thoughts and actions in time and space; Owen, 1997) was measured as TOL task, and response inhibition (i.e., the ability to resist temptations and actions impulsively; Diamond, 2013) was measured as the Stroop Color and Word Task (SCWT). It was predicted that young adults with ID would receive cognitive benefits after the unified flag football

program. They would improve the performance in digit span task, TOL task, and SWCT.

Method

Participants

Convenience sampling was conducted for this pilot study. Twelve young adults with ID (10 male, 2 female, aged 19 to 23 years old; Table 1) participated. They attended a 4-year federally approved comprehensive transition and postsecondary program for individuals with intellectual or developmental disabilities at a university in the Southeastern United States. The range of IQ level was 56 to 80. Participants were able to live independently on campus and select at least one college-level course per semester to audit or take for credit. Therefore, they were considered to have the ability to comprehend the instruction and express their feeling during the study.

Prior to the study, the interested parents/guardians and participants were given the informed consent forms for their signature. The Physical Activity Readiness Questionnaire (PAR-Q) determined if participants had any cardiovascular, physical, or visual issues that may have exacerbated their physical performance, and no participants required further medical examination before the program. the Human Subjects Institutional Review Board of our University approved all protocols.

Table 1
Summary of Participants' Characteristics

Characteristic	Total (n = 12) $M \pm SD$
Chronological age (years)	22.67 ± 1.69
Height (cm)	169.25 ± 6.67
Weight (kg)	72.17 ± 13.15
BMI (kg/m^2)	25.32 ± 5.25

Measures

Digital Span Task

The digital span task, a test of verbal working memory capacity, the cognitive ability of a person to store and manipulate information on a transient period, was used in this study. A list of digits was verbally administered at a rate of one per second. It consisted of two subtests: forward-span and backward-span. In the forward-span subtest, participants attempted to repeat the digits in the same order they heard from the examiner. In the backward-span subtest, participants attempted to repeat the digits in the reverse order the examiner presented. Every length of digit span consisted of two trials. For both subtests, after two successful trials, the number of digits was increased by one for the next level. The score was recorded after participants made errors for two trials in a row for a given digit span. It represented the maximum number of digits correctly recalled. The digit span task has been used in individuals with ID (Henry & MacLean, 2003).

Tower of London (TOL) Task

The TOL version from the NEPSY (Korkman et al., 1998) was used because of its applicability for use with typically developing children, who have similar mental age with the participants. TOL tested cognitive planning proficiency, the cognitive ability to plan ahead within a given time. The test consisted of a set of three pegs with three balls of different colors on the wooden base. The examiner displayed a new pictured goal-state on each puzzle. The participants were requested to match the color of balls from the original goal-state to a pictured arrangement within a certain number of moves. The test–retest reliability coefficient reported in the NEPSY manual in the typically developing children with similar mental age was approximately .89 (Korkman et al., 1998).

Stroop Color and Word Task (SCWT)

The SCWT, a well-known test of cognitive ability to inhibit response and select attention (Stroop, 1935), was used in this study. The task consisted of a list of names of the colors printed in an incongruent color of ink. The list has 24 stimuli. Participants were asked to name the color of the ink as quickly as possible and not to read the

word itself. The number of errors was registered and determined the individual's response inhibition and reaction to cognitive pressures. The SCWT has also been used in individuals with ID (Hartman et al., 2017).

Procedure

The pretest session was scheduled a week before the unified flag football program began. Upon participants' arrival at the laboratory, the anthropometric variables were recorded (i.e., chronological age, height, weight, and body mass index). Participants with ID were asked to fill out the PAR-Q. This helped us to screen for previous health issues that exercise may exacerbate. Participants with ID were also asked to perform the digit span task, TOL task, and SCWT as the pretest measures. After pretest measures, participants started the unified flag football training program. The instructors possessed much practical experience in teaching adults with ID. Seven university students (1 male, 6 female) also joined the program as sport partners.

Each training session lasted 50 min, twice a week for 15 weeks. The training session consisted of three components: warm-up exercises, football drills practice, and cooldown activities. Because it was an inclusive program, participants with ID practiced with partners each session throughout the football program, which promoted physical performance (e.g., speed, agility) and mastery of the specific drills (e.g., passing, receiving, team play). Hence, participants with ID had the opportunity to develop interactive experiences with typically developing partners. Further, the usage of the words "intellectual disability," "disabled," and "special needs" were not allowed, which promoted an inclusive environment. After the training program, participants with ID were scheduled for the posttest session in the laboratory. Each participant performed the digit span task, TOL task, and SCWT again as posttest measures. The order of EF tasks across pretest and posttest sessions was counterbalanced, which reduced the possibility of learning or habituation effects.

Data Analysis

Statistical analyses were performed with SPSS 25.0. This was a pre–post study design for measurement of changes resulting from a football training program. Considering the low power and violation

of the assumption of normality because of the small sample size, the Wilcoxon signed-rank test was utilized. The Wilcoxon signed-rank test is the nonparametric test equivalent to the dependent *t* test in which the median values were used. It compared the performance in each dependent measure (i.e., digit span task, Tower of London task, and Stroop color and word task) between pretest and posttest. The statistical significance was assessed at an alpha level of .05. Due to multiple comparisons, this study used the Hochberg adjustment method to adjust the *p* value to control Type I errors.

Results

Digit Span Task

As Figure 1 shows, in the forward-span, a Wilcoxon signed-rank test indicated that posttest ranks were not statistically significantly higher than pretest ranks, $Z = -1.00$, $p = .317$, $r = .267$ (the adjusted significant level was .0167). It indicated that the performance in the posttest measure ($M = 4.33$, $SD = .89$) was not significantly different than that in the pretest measure ($M = 4.08$, $SD = 1.08$).

In the backward-span, a Wilcoxon signed-rank test indicated that posttest ranks were not statistically significantly higher than pretest ranks, $Z = -.333$, $p = .739$, $r = .571$ (the adjusted significant level was .0125). It indicated that the performance in the posttest measure ($M = 2.25$, $SD = 1.14$) was not significantly different than that in the pretest measure ($M = 2.08$, $SD = .79$).

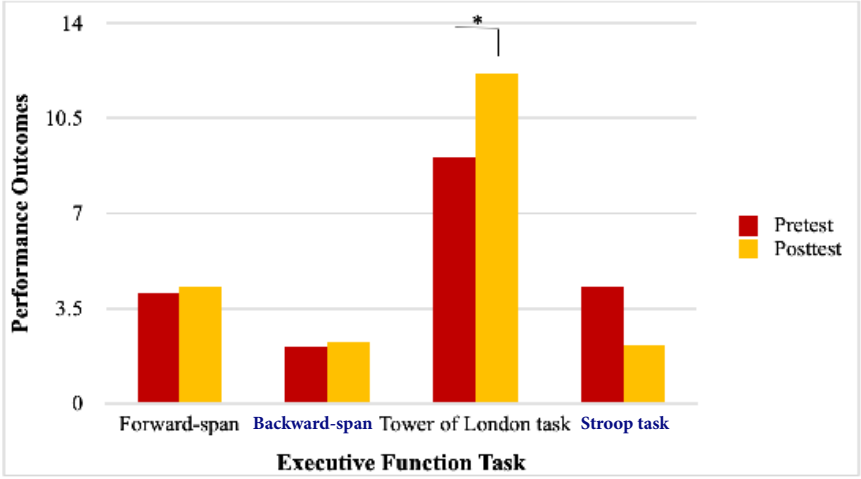
Tower of London Task

As Figure 1 shows, a Wilcoxon signed-rank test indicated that posttest ranks were statistically significantly higher than pretest ranks, $Z = -2.095$, $p = .036$, $r = .181$ (the adjusted significant level was .05). It indicated that the performance in the posttest measure ($M = 12.17$, $SD = 3.97$) was significantly different than that in the pretest measure ($M = 9.08$, $SD = 5.28$). Participants with ID solved more puzzles after the unified football program.

Stroop Color and Word Task

As Figure 1 shows, a Wilcoxon signed-rank test indicated that posttest ranks were not statistically significantly higher than pretest ranks, $Z = -1.912$, $p = .056$, $r = .218$ (the adjusted significant level

Figure 1
Performance Outcomes in Executive Function Task



was .025). Although participants with ID made fewer errors after the unified football program, the performance in the posttest measure (M = 2.17, SD = 2.98) was not significantly different than that in the pretest measure (M = 4.33, SD = 4.48).

Discussion

This study shows the effect of a unified flag football program for young adults with ID on three components of EF: working memory, cognitive planning, and response inhibition. Overall, our behavioral evidence shows differential associations between specific EF and football performance in young adults with ID. This study suggests that after practicing football with typically developing partners, participants with ID significantly perform better cognitive planning proficiency. To our best knowledge, this is the first study to indicate the connection between flag football sport participation and EF task performance among young adults with ID.

Working Memory

Working memory plays a significant role in higher cognitive functioning, such as thinking, planning, reasoning, and decision making. Working memory is vital in the decision-making process

during sport because athletes may need to retrieve relevant memories to interpret the situation and process information quickly in the decision-making process (Furley & Memmert, 2010). However, inconsistent with our hypothesis, participants with ID did not improve their performance in the digit span task after training program. Given that football has become one of the most popular sports in the United States, participants with ID may have already watched and even played football when they were in high school. Thus, the participants with ID had already stored, structured, and organized knowledge-based football memory in various memory systems. In this regard, this had become an automatic process without conscious involvement during practice. Participants with ID might have been able to retrieve useful information and communicate with their partners efficiently. Therefore, this may explain why participants with ID would not be able to receive the cognitive benefits in working memory capacity afterward.

Cognitive Planning and Response Inhibition

Cognitive planning is an evaluative and inferential process that participants use to retrieve the stored memory before initiating a movement response. To promote inclusion in this study, participants with ID were assigned to different partners who possessed different levels of motor skills each week. While practicing football drills with partners, participants with ID were trained to perceive relevant information quickly and accurately under the many spatial and temporal constraints imposed on them. As a result, the improvement in the TOL task in this study may represent that participants with ID can perceive environmental properties, identify certain cues, and even develop the perceptual strategies that can result in better prediction of each play.

On the other hand, response inhibition is another important element in sport. Football is an open-skill sport. To maintain optimal attentional focus, participants with ID may need to exhibit high cognitive flexibility to select relevant information and block the disruptive information in the environment during football practice. Thus, the benefits from football training may facilitate visual focusing on relevant target skills that might be associated with the performance in SCWT. In this study, participants made fewer errors in SCWT; however, the differences did not reach a significant level.

Underlying Mechanisms

Past studies reveal a significant linkage between cognitive skills and athletic performances (Cona et al., 2015; Vestberg et al., 2017). Further, the elite athletes have better EF performance than nonathletes (Verburgh et al., 2014). Every motor action includes a cognitive component. Exemplarily, a football player might need to focus attention on an opponent's movements, adjust continuously his attentional focus to the changing constraints in the environment, filter destructive thoughts and irrelevant information, and keep in mind and update the tactical approaches. Consistent with Vogt et al. (2012) and Chen et al. (2019), this study shows that physical performance (i.e., treadmill, soccer) may enhance performance in cognitive tasks among young adults with ID. Thus, physical performance may elevate levels of blood flow and neurotransmitters in the cerebral areas that may lead to cognitive improvement (Lista & Sorrentino, 2010; Vaynman et al., 2004). Moreover, sport training may stimulate the brain to analyze all the information that the participants with ID are exposed to, enabling participants with ID to make the correct decisions during practice. Yet only behavioral evidence was collected in this study. Psychophysiological instruments, such as electroencephalography (EEG) or blood tests, can be applied in future studies as part of an examination of the changes in the neural levels for verification of the cognitive effect of sport training among individuals with ID.

Limitations and Future Studies

Although the findings of this study demonstrate the cognitive beneficial effects of a unified flag football program in young adults with ID, the study has some limitations. First, convenience sampling is a limitation. Second, our results show no significant difference in the response inhibition aspect of EF, with moderate to strong effect size. This preliminary result is promising but needs to be replicated with a larger sample size for the effectiveness of the sport program to be validated. Third, psychophysiological measures (e.g., EEG, blood tests) can help to validate the association between football and EF in this population. Finally, some participants' experience in football is another limitation. This study does not measure their levels of sport

skill. Future studies may include the past sport experience as the covariant into data analysis.

Conclusion

In summary, the impact of flag football may vary on different aspects of EF. Flag football participation may enhance the cognitive planning aspect of EF in young adults with ID. For parents, physical education teachers, and coaches, this preliminary outcome provides useful knowledge regarding sports and cognitive development that flag football participation might be associated with the improvement in EF among individuals with ID.

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