Global Journal of Intellectual & Developmental Disabilities
ISSN: 2575-8586

Juniper Publishers
key to the Researchers

Research Article
Volume 8 Issue 2 - May 2021
DOI: 10.19080/GJIDD.2021.08.555733

Glob J Intellect Dev Disabil

A Preliminary Exploration of Relationships between Executive Functioning and Motor Skills in Young Adults with Intellectual Disabilities

Chen C.-C. (JJ)[1], Ringenbach SDR[2], Ryuh YJ[3] and Hardwick H[1]

[1]*Department of Kinesiology, Mississippi State University, MS State, USA*

[2]*College of Health Solutions, Arizona State University, Phoenix, USA*

[3]*Department of Kinesiology, Sonoma State University, Rohnert Park, USA*

Submission: April 16, 2021; **Published:** May 13, 2021

***Corresponding author:** Chen C.-C. (JJ), Department of Kinesiology, Mississippi State University, MS State, USA

Abstract

Background: This study was to provide an empirical evidence that executive function (EF) and motor performance are related among adults with intellectual disabilities (ID).

Methods: Twelve adults with mild to moderate ID, aged 20.83 ± 1.47 yrs. performed the Eriksen Flanker Test (i.e., selective attention) and Corsi Block Tapping Test (i.e., spatial working memory) as measures of EF. Purdue Pegboard Test (i.e., manual dexterity) and Special Olympics Football (i.e., soccer) Skill Test were adopted as motor measures. Spearman correlation analysis was then computed to analyze the correlations among the variables.

Results: The performance of the Eriksen Flanker Test in the incongruent condition was significantly related to soccer skill, whereas a conventional level of significance was found between the performance of the Eriksen Flanker Test in the congruent condition and manual dexterity. In addition, the performance in the Corsi Block Tapping Test was not related to manual dexterity and soccer skills. Furthermore, the performance of manual dexterity and soccer skill was significantly correlated with each other.

Conclusion: This study supported the interplay of cognitive and motor functioning in individuals with ID. Our findings highlight the need for more studies to enhance the knowledge of cognition-motor skill relationships for persons with ID.

Keywords: Manual Dexterity; Football; Cognition; Intellectual Disabilities

Abbreviations: ID: Intellectual Disabilities; DS: Down Syndrome; ADL: Activities of Daily Living; PAR-Q: Physical Activity Readiness Questionnaire

Introduction

Traditionally, human cognition and motor function have been studied separately and it is generally believed that cognitive development relies on motor development [1]. However, more recent studies [2,3] revealed that the dorsolateral prefrontal cortex and cerebellum, responsible for the higher-order executive function and motor coordination respectively, showed co-activation in cerebellar patients while performing many executive function tests, such as verbal fluency [4,5], set-shifting tasks [4], and working memory tasks [6]. Hence, recent studies indicated a possible association between human cognition and motor function in typical populations and the suggest that impaired executive function may adversely affect motor performance and vice versa [7,8].

In accordance with the theoretical evidence, Hartman, Houwen, Scherder, and Visscher [9] indicated similar relations in individuals with intellectual disabilities (ID). Hartman et al. [9] found that cognitive planning, measured as Tower of London Test, and motor measurement outcome in the Test of Gross Motor Development were highly related in children with ID. That is, children with ID who had a low level of cognitive planning ability performed poor object control skills. In addition, Chen, Ringenbach, Albert, and Semken [10] reported that cognitive planning, measured by the Tower of London Test, was related to the performance of manual dexterity in adolescents and young adults with Down syndrome (DS). Participants who solved more puzzles placed more pieces within the given time during the Purdue Pegboard Test. Both

studies considered the cognitive planning aspect of executive function in individuals with ID; however, accumulated evidence has indicated the selective attention and spatial working memory might be also important for the success in motor and sport performance [11-13]. For example Abernethy [11] found expert badminton players displayed better attentional shifts on critical information than the novices. Thus, one of the innovations of this study was to investigate the relationships between selective attention and working memory aspects of executive function and motor performance in individuals with ID.

Furthermore, manual dexterity was employed to assess motor function in the upper extremities because the impaired manual dexterity might limit the ability to independently perform daily motor sequential tasks (e.g., brushing teeth, brushing hair, etc.). Marchini, Vieira, Bossan, Montenegro, and Cunha [14] reported denture-related stomatitis showed a statistical relationship with impaired manual dexterity in 533 elderly people. Data from 164 persons with multiple sclerosis showed that manual dexterity, measured with the Nine-hole Peg Test, was associated with independence in activities of daily living (ADL) and instrumental ADL indexes [15]. In particular, working memory, measured as digit span backward test, was associated peak displacement in the Purdue Pegboard Test in young adults [16].

Moreover, another innovation of this study was employed a sport-specific motor skill (i.e., soccer dribbling, shooting, and passing) to assess motor function in the lower extremities. Soccer was adopted due to its worldwide popularity [17]. Vestberg et al. [18] indicated the level of working memory function was correlated with the number of goals the soccer players performed during the season. Based on the previous studies, motor skills in manual dexterity and soccer skill seem to have a connection with executive function in people with ID.

In summary, the purpose of the present study was to increase empirical knowledge that there was a relationship between executive function and motor performance in young adults with ID. Executive function was measured with the Eriksen Flanker Test (i.e., selective attention) and Corsi Block Tapping Test (i.e., spatial working memory). Motor performance was measured with the Purdue Pegboard Test (i.e., manual dexterity) and Special Olympics Soccer Skill Test. Consistent with previous studies [16,19], we hypothesized that the selective attention and spatial working memory might be related to the motor function in the upper and lower extremities in persons with ID.

Method

Participants

A total of 12 participants with mild to moderate ID (9 males and 3 females, 20.83 ± 1.47 yrs.) participated in the present study. Participants with ID were enrolled in a university transitional education program. They lived independently on campus and attended university courses for audit or credits. Thus, they were perceived to have the capability to comprehend the instruction regarding the test protocols used in the present study. The demographic information of the participants was illustrated in Table 1. Prior to the study, all participants, as well as parents/guardians of participants with ID, provided their informed consent to participate in this study. In addition, the Physical Activity Readiness Questionnaire (PAR-Q) was conducted to evaluate if there were any cardiovascular or musculoskeletal issues that may acerbate their participation. If participants answered "no" to all questions, there was no need to receive further medical clearness from their physicians. All protocols were approved by the Human Subjects Institutional Review Board at the University.

Table 1: Spearman correlation among manual dexterity, soccer skill, and executive function.

	1	2	3	4	5
1. EFT-C	-	0.538	-0.036	-0.462	-.732*
2. EFT-In		-	-0.178	-0.545	0.385
3. Corsi			-	0.249	0.094
4. PPT				-	.606*
5. SST					-

Note. * = $p < .05$
EFT-C = Eriksen Flanker Test-Congruent; EFT-In = Eriksen Flanker Test-Incongruent; Corsi = Corsi Block Tapping Test; PPT = Purdue Pegboard Test; SST: Soccer Skill Test.

How to cite this article: Chen CC, Ringenbach S, Ryuh YJ, Hardwick H. A Preliminary Exploration of Relationships between Executive Functioning and Motor Skills in Young Adults with Intellectual Disabilities. Glob J Intellect Dev Disabil, 2021; 8(2): 555733. DOI: 10.19080/GJIDD.2021.08.555733

Procedure

Upon arrival at the laboratory, the participants were asked to participate in the three stations in order. In the first station, age, PAR-Q, handedness, and leg dominance were assessed. Handedness and leg dominance were considered in order to perform the Purdue Pegboard Test and Soccer Skill Test. In the second station, the computerized Eriksen Flanker Test and Corsi Block Tapping Test were performed through the website (i.e., cognitivefun.net). Purdue Pegboard Test, in the third station, was conducted to measure the participant's manual dexterity. The entire session lasted approximately 35 to 40 minutes. A week later, Special Olympics Football Skill Test was implemented to assess all participants' soccer skills in the indoor gymnasium. The Soccer Skill Test for all participants lasted about an hour.

Measurement

Manual dexterity

Purdue Pegboard Test: The Purdue Pegboard (model 32020, Lafayette Instruments, Lafayette, IN, U.S.A.) has been widely used in measuring unimanual and bimanual dexterity, which of test-retest reliability is reported as 0.92 - 0.96 [20]. The pegboard consists of four bins across a top and two vertical rows of 25 holes which forms parallel to each other. From left to right, the bins contain 25 pegs, 40 washers, 20 collars, and 25 pegs. For the present study, we used the dominant hand, non-dominant hand, bimanual, and assembly subtest. The participants were asked to sit at the testing table having the Purdue Pegboard directly in front of them and place their hands behind the starting line located in between four bins and a top hole of both vertical rows. Each subtest was carried out three times consecutively, and the average score among the three trials was recorded. After completion, the sum of the four subtest scores was recorded for the data analysis.

Soccer skill

Special Olympics Soccer Skill Test: Special Olympics Unified Sports Course Module 2: Football Guide was employed for soccer skill test. In the module, there is a Football (i.e., soccer) Skills Assessment Test composed of dribbling, shooting, and passing skill. Dribble station was 12-meter slalom with five cones. The distance between cones was 2 meters apart and staggered 0.5 meters from the central line. The participant was asked to weave through the slalom as fast as possible and the performer got 5 points at each time past a cone. After they went through the slalom, the performer stopped the ball and ran back to start with a new ball from the starting line. The participant performed the dribble task for 1 minute.

Shooting skill assessment took place in the penalty area 8-meter away from a regular indoor soccer goal with nets. The participant was initially located from the line 8-meters away from the goal and asked to get into the penalty area with a ball and shoot the ball toward the goal for one minute. Each participant scored 10 points for each successful loft-shoot, and 5 points for each successful shot that touched the ground.

As for the passing skill assessment, the participant received a ball rolled by a tester and dribbled through the passing gate 7-meter away from their starting line. After dribbling through the gate, the participant was asked to pass to the target either 45^0 left or right side, 10-meter away from the passing gate, and it was 3-meter wide. A tester alternatively assigned the left and right target for the participant to pass. The participant scored 10 points for each successful pass through a target gate. The sum of three skill test scores was used for the data analysis.

Executive function measures

Eriksen Flanker Test: The Eriksen Flanker Test [21] is one of the popular response interference tasks, is a set of selective attention trials. During the test, a central target arrow (i.e., left or right) is shown simultaneously with two or more distractor arrows. The goal for the test was to respond only to a central target as fast as possible while inhibiting the response to the two or more distractor arrows on either side of the central target. We used the test in a free-accessible website (i.e., cognitivefun.net). There is a total of 20 trials which consisted of congruent (i.e., the direction of the center arrow and the other arrows are the same) and incongruent trials (i.e., the direction of the center arrow and the other arrows are opposite). Within 20 trials, the order of congruent and incongruent tasks was randomized.

The participant was asked to sit in front of a computer and put their index fingers on both left and right arrow keys. During the test, the participant was asked to respond by pushing either the left or right key in accordance with the direction of the central arrow as fast as possible. Congruent and incongruent response time was recorded to the nearest milliseconds, as well as accuracy was recorded to the nearest 5 %.

Corsi Block Tapping Test. The Corsi Block Tapping Test, originally developed by Corsi [22], is one of the widely utilized visuospatial working memory tests in both the clinical and academic realm [23]. The test was from the same free-accessible website where the Eriksen Flanker Test was adopted (i.e., cognitivefun.net). Each participant was asked to sit in front of the computer monitor and place their dominant hand on the table. The monitor had a touchscreen function which enabled the participant to directly click the intended block (i.e., square image on monitor) with a finger. During the test, the participant was asked to memorize the order of the blocks that get marked among the 12 blocks, then reproduce the order by touching the block. The length of the memory span started from 3 blocks. Once an individual succeeded on two consecutive trials, the memory span was increased by one block and the test proceeded until the performer made two consecutive failures. The performance score was recorded as the longest length of blocks that the performer was able to successfully reproduce on two consecutive trials.

How to cite this article: Chen CC, Ringenbach S, Ryuh YJ, Hardwick H. A Preliminary Exploration of Relationships between Executive Functioning and Motor Skills in Young Adults with Intellectual Disabilities. Glob J Intellect Dev Disabil, 2021; 8(2): 555733. DOI: 10.19080/GJIDD.2021.08.555733

Data analysis

The present study aimed to verify the relationship between executive functioning and motor performance manual dexterity and soccer skills. Due to the small sample size, Spearman correlation was then computed to examine the correlations among the variables. The significant alpha level was set at .05 (two-tailed).

Results

Correlation between executive function and manual dexterity

As seen in table 1, the reaction time in Eriksen flanker test congruent condition (M = 1106.42 ± 424.17 ms) did not show a significant correlation with the Purdue Pegboard Test performance (M = 35.53 ± 10.18), r = -.462, p = .131. However, the reaction time in the Eriksen flanker test incongruent condition (M = 1329.76 ± 472.08 ms) showed trend towards conventional level of significance with Purdue Pegboard Test performance, r = -.545, p = .067. In addition, the working memory capacity measure in the Corsi Block Tapping Test (M = 3.83 ± 1.53 blocks) did not show a significantly correlation with Purdue Pegboard Test performance, r = .094, p = .770.

Correlation between executive function and soccer skill

As seen in table 1, the reaction time in Eriksen Flanker Test congruent condition and soccer skill (M = 110.83 ± 32.11 points) were negatively correlated, r = -.732, p = .007. However, the reaction time in the Eriksen Flanker Test incongruent condition and soccer skill did not have a significant correlation, r = -.385, p = .216. The performance in Corsi Block Tapping Test did not display any significant relationship with soccer skill, r = .094, p = .770. Taken together, soccer skill was related to the selective attentional capacity in adults with ID but not spatial working memory function.

Correlation between manual dexterity and soccer skill

As shown in Figure 1, the performance in the Purdue Pegboard Test and soccer skill had a significantly positive correlation, r = .606, p = .037. It suggested that the motor functions in the upper and lower extremities were significantly positively related in adults with ID.

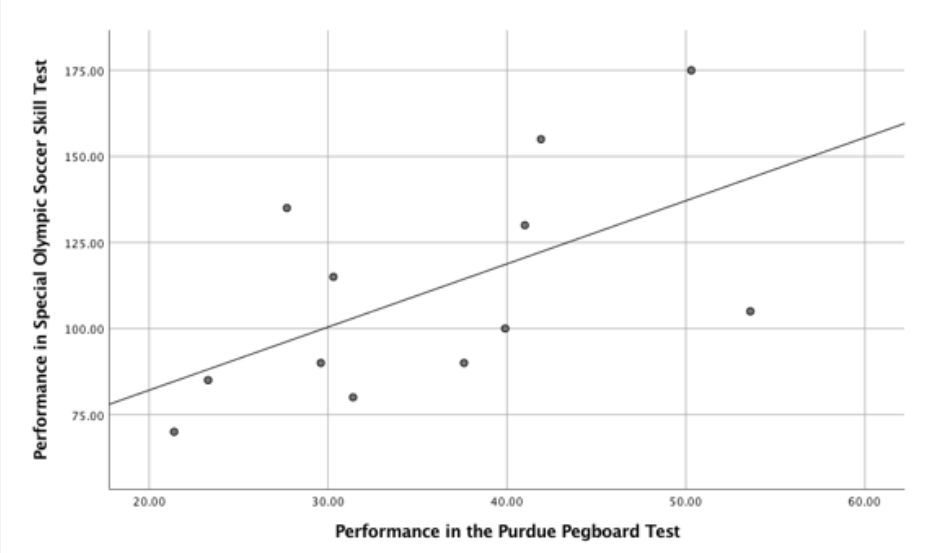

Figure 1: The association between the performance in the Purdue Pegboard Test and Special Olympics Soccer Skill Test.

Discussion

The present study examined the relationships between executive function and motor performance in adults with ID. First, the negative association between the reaction time in Eriksen Flanker Test congruent condition and soccer skill scores were indicated. Hence, it seems that the better performance (i.e., faster reaction time) in selective attentional capacity the better soccer performance. In addition, the conventional level of significance was shown the negative relation between the reaction time in Eriksen Flanker Test incongruent condition and the Purdue Pegboard Test scores. Both results may illustrate the interplay between selective attentional capacity and motor performance in adults with ID. Furthermore, a positive relation between the performance in the upper extremities (i.e., the Purdue Pegboard Test) and the lower extremities (i.e., soccer test) was demonstrated in this population.

The spatial working memory capacity, measured with the Corsi Block Tapping Test, did not exhibit a positive association

How to cite this article: Chen CC, Ringenbach S, Ryuh YJ, Hardwick H. A Preliminary Exploration of Relationships between Executive Functioning and Motor Skills in Young Adults with Intellectual Disabilities. Glob J Intellect Dev Disabil, 2021; 8(2): 555733. DOI: 10.19080/GJIDD.2021.08.555733

with manual dexterity, measured as the Purdue Pegboard Test in the present study. This result is consistent with Chen et al. [24] who reported that the Purdue Pegboard Test scores in adolescents and adults with DS were associated with verbal working memory capacity, measured as the Auditory Memory Span Test but not spatial working memory capacity, as measured by the Corsi Block Tapping Test. Further, spatial working memory capacity did not show a relationship with soccer skill performance. According to Maxwell, Masters, and Eves [25], declarative knowledge is the knowledge that can be verbally explained, and requires working memory, whereas the procedural knowledge is normally equipped by implicit learning and it does not require working memory capacity during motor skill acquisition. Traditionally, it is believed that learners typically utilize the declarative knowledge during the early stages of learning, and gradually proceed to the utilization of the procedural knowledge as they become skillful [26]. A finding in line with this proposal is that words held in working memory facilitated visual search of semantically related visual objects in young adults [27]. In the present study, participants with ID had little experience in the Purdue Pegboard Test and soccer activity. Also, there was no feedback regarding their performance during tests. Thus, the participants might not utilize the declarative knowledge to activate the circuitry of working memory during the performance. This could explain why no relationship was found between soccer skill performance and spatial working memory capacity in the present study. Future studies should include verbal working memory tests to understand its role in motor performance.

Additionally, selective attention had a negative relationship with soccer skill performance. Soccer skill arguably possessed an aiming task such as visually searching the moving ball, contact accurately with the foot, and focusing on the target (i.e., goal or passing target). Bekris, Gissis, Ispyrlidis, Mylonis, and Axeti [28] supported this argument by reporting that visual selective attention is positively related to the soccer dribbling competency in soccer players. That is, participants with lower selective attention capacity might tend to correct their movement more frequently than those with higher function in an attentional domain. Therefore, a high level of selective attention might result in the decreased "careless movement" and better manual dexterity and soccer ball manipulation in participants with ID.

Lastly, manual dexterity and soccer skill assessment scores showed a significant relationship. It appears to have a connection in motor function between the upper and lower extremities. To date, several studies demonstrated that the improvement in upper motor function (e.g., manual dexterity) could result from the training in the lower extremities. Chen, Ringenbach, & Albert [24] found participants with DS improved the performance in the Purdue Pegboard Test after a 30-minute acute assisted cycling therapy. Soyupek, Bölükbaşı, Yorgancıoğlu, and Gökoğlu [29] found that people with coronary artery disease improved fine manual dexterity after an acute 30-min treadmill walking exercise with moderate intensity. Based on these findings, there seems to be a connection between lower and upper body motor function across different populations which may indicate neural changes in the motor cortex.

Despite the significant findings, the present study had several limitations. First, the study needs to be replicated with a larger sample size because there were relationships with moderate to strong effect sizes. Thus, this preliminary result is promising but needs to be replicated with a larger sample. Another limitation regarding the sample was the sex distribution which is the fact that only three participants with ID were females. This was because the recruitment process primarily relied on volunteering. Therefore, a subsequent study will need to consider more female participants. Moreover, it is recommended that future studies should also include other executive function measures, such as verbal working memory, to identify the potential role of the relationship between executive function and motor performance.

In summary, the findings can be considered as a steppingstone in a practical setting. This study is necessary as it begins to uncover the mechanisms responsible for the existence of relationships between executive function and motor performance in young adults with ID. From a theoretical perspective, the improved motor performance (e.g., manual dexterity, sport skills) may exert a positive impact on executive function. Therefore, the findings in the present study can encourage practitioners to develop appropriate interventions in improving both executive function and motor performance at the same time which will ultimately improve the quality of life for persons with ID.

References

1. Piaget J, Inhelder B (1969) The Psychology of the Child. New York, NY: Basic Books.
2. Diamond A (2000) Close interrelation of motor development and cognitive development and of the cerebellum and prefrontal cortex. Child development 71(1): 44-56.
3. Stoodley CJ, Schmahmann JD (2009) Functional topography in the human cerebellum: A meta-analysis of neuroimaging studies. Neuroimage 44(2): 489-501.
4. Schmahman JD, Sherman JC (1998) The cerebellar cognitive affective syndrome. Brain 121: 561-579.
5. Botez MI, Botez T, Elie R, Attig E (1989) Role of the cerebellum in complex human behavior. Italian Journal of Neurological Sciences 10(3): 291-300.
6. Fiez JA, Raife EA, Balota DA, Schwarz JP, Raichle ME, et al. (1996) A positron emission tomography study of the short-term maintenance of verbal informationtion. Journal of Neuroscience 16(2): 808-822.
7. Becker DR, McClelland MM, Geldhof GJ, Gunter KB, MacDonald M (2018) Open-skilled sport, sport intensity, executive function, and academic achievement in grade school children. Early Education and Development 29(7): 938-955.
8. Livesey D, Keen J, Rouse J, White F (2006) The relationship between measures of executive function, motor performance and externalising behaviour in 5-and 6-year-old children. Human Movement Science, 25(1): 50-64.

How to cite this article: Chen CC, Ringenbach S, Ryuh YJ, Hardwick H. A Preliminary Exploration of Relationships between Executive Functioning and Motor Skills in Young Adults with Intellectual Disabilities. Glob J Intellect Dev Disabil, 2021; 8(2): 555733. DOI: 10.19080/GJIDD.2021.08.555733

9. Hartman E, Houwen S, Scherder E, Visscher C (2010) On the relationship between motor performance and executive functioning in children with intellectual disabilities. Journal of Intellectual Disability Research 54(5): 468-477.

10. Chen CC, Ringenbach SDR, Albert A, Semken K (2014) Fine motor control is related to cognitive control in adolescents with Down syndrome. International Journal of Disability, Development and Education 61(1): 6-15.

11. Abernethy B (1988) The effects of age and expertise upon perceptual skill development in a racquet sport. Research quarterly for exercise and sport 59(3): 210-221.

12. Memmert D, Simons DJ, Grimme T (2009) The relationship between visual attention and expertise in sports. Psychology of Sport and Exercise 10(1): 146-151.

13. Vestberg T, Reinebo G, Maurex L, Ingvar M, Petrovic P (2017) Core executive functions are associated with success in young elite soccer players. PloS one 12(2): e0170845.

14. Marchini L, Vieira P C, Bossan TP, Montenegro FLB, Cunha VPP (2006) Self-reported oral hygiene habits among institutionalised elderly and their relationship to the condition of oral tissues in Taubaté, Brazil. Gerodontology 23(1): 33-37.

15. Kierkegaard M, Einarsson U, Gottberg K, von Koch L, Holmqvist LW (2012) The relationship between walking, manual dexterity, cognition and activity/participation in persons with multiple sclerosis. Multiple Sclerosis Journal 18(5): 639-646.

16. Rodríguez-Aranda C, Mittner M, Vasylenko O (2016) Association between executive functions, working memory, and manual dexterity in young and healthy older adults: An exploratory study. Perceptual and motor skills 122(1): 165-192.

17. Hulteen RM, Smith JJ, Morgan PJ, Barnett LM, Hallal PC, et al. (2017) Global participation in sport and leisure-time physical activities: A systematic review and meta-analysis. Preventive Medicine 95: 14-25.

18. Vestberg T, Reinebo G, Maurex L, Ingvar M, Petrovic P (2017) Core executive functions are associated with success in young elite soccer players. PloS one 12(2): e0170845.

19. Buszard T, Masters RS, Verswijveen S, Farrow D (2016) The influence of working memory capacity on children's motor learning: Evidence from a basketball task. Journal of Sport & Exercise Psychology 38: 48-49.

20. Gallus J, Mathiowetz V (2003) Test-retest reliability of the Purdue Pegboard for persons with multiple sclerosis. American Journal of Occupational Therapy 57(1): 108-111.

21. Eriksen CW, Schultz DW (1979) Information processing in visual search: A continuous flow conception and experimental results. Perception & Psychophysics 25(4): 249-263.

22. Corsi P (1972) Memory and the medial temporal region of the brain. Unpublished doctoral dissertation. McGill University, Montreal, QB.

23. Kessels RP, Van Zandvoort MJ, Postma A, Kappelle LJ, De Haan EH (2000) The Corsi block-tapping task: standardization and normative data. Applied Neuropsychology 7(4): 252-258.

24. Chen CC, Ringenbach SDR, Albert AR (2014) Assisted cycling exercise improves fine manual dexterity in persons with Down's syndrome. Journal of Applied Research in Intellectual Disabilities 27(3): 264-272.

25. Maxwell JP, Masters RSW, Eves FF (2003) The role of working memory in motor learning and performance. Consciousness and Cognition 12(3): 376-402.

26. Fitts PM, Posner MT (1967) Human performance. Belmont, CA: Brooks/Cole.

27. Huettig F Altmann GT (2005) Word meaning and the control of eye fixation: semantic competitor effects and the visual world paradigm. Cognition 96(1): 23-32.

28. Bekris E, Gissis I, Ispyrlidis I, Mylonis E, Axeti G (2018) Combined visual and dribbling performance in young soccer players of different expertise. Research in Sports Medicine 26(1): 43-50.

29. Soyupek F, Bölükbaşı N, Yorgancıoğlu Z, Gökoğlu F (2006) The effect of aerobic exercise on hand strength and dexterity of patients with coronary artery disease. Turkiye Fiziksel Tip ve Rehabilitasyon Dergisi 52: 72-75.

DOI: 10.19080/GJIDD.2021.08.555733

How to cite this article: Chen CC, Ringenbach S, Ryuh YJ, Hardwick H. A Preliminary Exploration of Relationships between Executive Functioning and Motor Skills in Young Adults with Intellectual Disabilities. Glob J Intellect Dev Disabil, 2021; 8(2): 555733. DOI: 10.19080/GJIDD.2021.08.555733