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Motor skills and school aged population with intellectual disability: Preliminary investigation

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Abstract
The purpose of this preliminary investigation was to review motor skill and school-aged children with intellectual disability based on the literature published before 2014. Next step will be to complete a review on motor skills and school aged children with intellectual disability based on the literature published between 2014 to 2023. The final step for this project will be to conduct a meta-analysis on motor skills of school-aged children with intellectual disability based on the current literature regarding motor skills and school-aged children with intellectual disability.

Keywords: Motor skills, intellectual disability, school-aged children, literature review, preliminary investigation

1. Introduction
Typically, individuals with intellectual disability indicated that they have lack of physical activity compared to population without disabilities [1, 2]. Low physical fitness and recent obesity issue could be attributed to inactive lifestyle including low engagement in physical activity [3, 4, 5]. Inactive lifestyle including low participation rate in physical activity are universally explained due to environmental and personal barriers [4, 5]. And those individuals with intellectual disability will be more likely to have environmental and societal limitations to participate in physical activity [6]. To characterize physical activity pattern of individuals with intellectual disability, several literature reviews have been completed [7, 8]. Frey, Temple, and Stanish (2008) conducted a series of literature review with respect to physical activity of adult population and youth who have intellectual disability, respectively. Both reviews indicated population with intellectual disability showed inactive lifestyle concurrently with mixed-results which attributed to methodological limitations such as insufficient data which yield difficulties to synthesize a clear conclusion. Similar to this, Hinckson & Curtison (2013) pointed out physical inactivity of children with intellectual disability although reviewed studies differ in design and methodology implying the importance of test validation for future study as well as the need of increase number of studies.
To participate in advanced level of physical activity, prerequisite skills are required. For instance, once completed efficient arm stroke for throwing, it does not need much effort to go to the next level. Moreover, appropriate skill level to participate in diverse activities individually or as a group based, initial movement and appropriate level of motor skill will be very important. Compared to individuals without disability, due to limitations with respect to participation in physical activity from early ages, individuals with intellectual disability would have difficulties to develop appropriate degree of motor skill which is required to participate in diverse and advanced level of physical activities according to developmental time. Well-developed fundamental motor skills are regarded as a basis in order to successfully engage in higher level of activities in diverse sports context. Furthermore, to develop enough motor skill level in early ages is important in that motor skill competence during the childhood will influence on active lifestyle in their later life as well [9].
Motor skill refers to intentional movement regarding physical activity of the body muscles for skill performance in exercise generally described as gross and fine motor skill.

Motor skill *learning* could be explained with diverse perspective with the concepts and domains regarding movement. Newell's constraints model (1986) well explained the importance of relationships between three key factors as organism, task, and environment with respect to the development of motor skill [10]. The interrelatedness of organism, task, and environment would provide informative explanation. Especially, individuals with intellectual disability have low cognitive level which could impede active learning. With considerations of low cognitive level, individualized environmental factors, and difficulties of tasks, people with intellectual disability could be supported to facilitate motor skill learning at the maximum extent. The purpose of this review focuses on diverse factors to understand the relationship of motor skills and school aged children with intellectual disability.

2. Materials and Methods

2.1 Method

To maximize physical activity participation, there is a need for comprehensive understanding of how individual with intellectual disability develop their motor skill learning. This literature review critically addressed the current research on motor skills learning and individuals with intellectual disability. *Keyword searches* were performed to identify articles from *the data bases* including Education Full Text, Eric, Medline, Library catalog, Physical Education Index, PsycINFO and Sport discuss from 1981 to June of 2014. Key words used were intellectual disability, mental retardation, cognitive impairment, developmental disability mixed with motor skill, sport skill, gross motor sill, fine motor skill, activities of daily living, and self-help skill. Additionally, secondary method reviewing reference list of each study performed to include overlooked studies.

The inclusion and exclusion criteria is like the followings; a) Full-text manuscripts, b) peer-reviewed articles, and refereed journals included. Practitioner, thesis, and dissertation paper were excluded, c) Original research articles published in English that measured motor skill learning of individuals with intellectual disability were included, d) Data-based articles: Motor skill is quantitatively or qualitatively measured in reviewed studies. The inclusion criteria for this review were motor skill as key outcomes, rather than physical activity, exercise or fitness, e) Study participants of articles preschool aged to secondary school aged, and f) Study participants were individuals with ID. Population with autism were excluded.

3. Results

3.1 Study Design

Out of twenty-four studies, twenty-two studies were quantitative method based. Among those studies, merely one study was conducted based on longitudinal approach. Other studies were conducted based on cross-sectional design. Two studies [32, 34] were single subject research and no qualitative study included.

3.2 Sampling (country and region)

Total of twenty-four reviewed studies, studies were conducted in diverse countries like the followings: twelve in the U.S.A, three (12.5%) conducted in Netherlands, three (12.5%) in Canada, one studies (25%) in Finland, Hong-Kong, Iran, South Korea, Taiwan, and Turkey, respectively. Generally, specific ethnicity or race were nor provided in the studies (except # 7). Of the twelve studies which were conducted in the U.S.A., eight studies took place in urban, one study was conducted both in urban and rural area, and three studies did not provide specific information. Out of twelve studies conducted outside of the U.S.A., seven studies were performed in the urban, two studies were conducted in urban and suburban at the same time, and three studies did not inform specific place location.

3.3 Participantsa

School-aged children with intellectual disability were included in the review. Of the twenty-four studies, ten articles [11, 15, 17, 18, 19, 21, 22, 25, 27, 30] included typically developing children together as the study participants. And two studies (18, & 19) included population with Down syndrome.

3.4 Gender

Of the twenty-four studies, four studies [14, 18, 19, 22] included only male participants. And three studies [16, 26, 27] did not provide information about gender of study participants.

3.5 Age

Study participants in the review aged from 3 to 19 years old; one study [33] included preschoolers with intellectual disability aged from 3 to 6 years old. Age groups were various within middle childhood and adolescents in the rest of studies reviewed.

3.6 The level of intellectual disability

Out of twenty-four studies, fifteen study included mild level of intellectual disability. Most of reviewed studies included mild level of intellectual disability. And three studies [12, 20, 21] included study participants with moderate to mild intellectual disability. Two studies indicated study population with mild intellectual disability and borderline intellectual disability (Intelligence Quotients in the 70s). Two studies [18, 19] indicated that study participants in the study included children with Down syndrome. Merely one study [32] included study participants with severe to profound level of intellectual disability.

3.7 Measures

To measure motor skills components of school-aged children with intellectual disability, a diverse set of instrumentations included in reviewed studies along with analysis of the data.

TGMD-2 were the most frequently used to measure motor skills [12, 13, 15, 25, 30]. Movement

Assessment Battery for Children (MABC) [29], and Survey: A modification of a perceived competence scale [10] were used once in reviewed studies. And diverse instrumentation was included in one study [31] including Brunkins-Oseretsky test pf motor proficiency (BOTMP), and Peabody developmental motor scales-2 (PDMS-2). Two other studies measure gross motor skill with a variety of tasks identified by the authors [17, 33].

Depending on the purpose, several components were examined within motor skills in the studies [11, 17]; motor skills persistence and accuracy of movement. In the study [11], gross motor *reaction* (movement time tasks with variations on the degree of uncertainty of movement) as outcome measure including three types of tasks; 4.6 m run, choice task, and pre cure task. In the study [11] which examined motor task persistence, two novel tasks dividing into gross and fine motor persistence were included.

Ten studies measured motor skills learning to investigate the effects of practice conditions [14, 16, 18, 19, 22, 23, 24, 26, 27, 28]. Each of these studies used different methods like the followings: a

golf-putting task (4), basketball free throw depending on different variations of mental and physical practice environment on motor skill learning, [16] a pursuit tracking task which examined accuracy of movement [18, 19], modified kicking task to see cognitive aspect [22], a beanbag tossing task to see the effect of knowledge of results (KR) feedback (every fifth trial) vs every trial [23], 4.57 m distance from three concentric circle targets throwing task using a baseball [24], the peg board/pursuit rotor task to examine motor task in terms of cognitive aspect depending on the imaginary practice [26], catch trials to see a response-type task [27] and throwing tasks to see the effects of imaginary practice condition [28].

Out of twenty-four studies, two studies [32, 34] were performed based on single subject research design to investigate specific strategy on motor skills learning. More specifically, 1 study included motor skills learning with the use of 4 second constant time delay (CTD) procedure with prompts as outcome measure. In the study, three tasks were used including one step bowling, overhand throwing and short distance putting. One study included motor (sports, leisure) skills learning with the use of 4 step strategy (ready, look, do, and so). In this study, three motor skills used including (basketball free throw, overhand softball throw, and dart throw).

To synthesize, reviewed studies were conducted in diverse countries and sub-areas including urban or suburban regional places. Most studies reported they recruited study population from school areas. Children with mild intellectual disability were main interest in terms of study sample. Generally, there were the lack of information regarding social economic status, and ethnicity or race in the reviewed studies. Due to the nature and the specific outcomes and components of interests by the authors, different methodology along with data collection/analysis procedures were described in each study. The findings were diverse and thus different strengths/weaknesses were described in the studies as well. Additionally, there were variability in each study regarding the description of study procedures with or without enough information such as validity/reliability of instrumentation. Thus, there should be a caution to interpret the data depending on how all the procedures were specifically described in each study.

Health-related fitness and fundamental motor skills [12, 13]

There were mixed results between studies examining the relationship between fundamental motor skills and health-related fitness measures. Increased fundamental motor skills and health related fitness were both related to reduction of body fatness [12]. However, in the study [13], the results indicated that motor skills and overweight and obesity is minimally negatively compromised compared to peers without ID.

The level of intellectual disability and motor skill performance [15, 17, 29, 30]

The degree of intellectual disability and motor skill performance were interrelated supporting the notion that motor performance and cognitive domain were related [29]. Low motor skill levels were interrelated to impairment in high-order executive function [15]. Typically developing children showed better motor skill performance. With age increases, children with and without intellectual disability improved level of motor skill performance. Additionally, when gender differences were present, differences were in favor of male students [17]. Compared to typically developing children, children with borderline and mild level of intellectual disability significantly scored less in loco-motor skills but not for object control skills and executive functioning [15]. Children with intellectual disability, borderline intellectual disability and general population group indicating significantly different level of performance in TGMD-2 [30].

Two studies in the review [18, 19] conducted to see motor characteristics of children with Down syndrome. The findings indicated that study participants with Down syndrome showed more difficulty in reaction to motor tasks while showed same pattern of movement once started to move.

Motor skill persistence, and perceived competence [20, 21]

With respect to motor persistence, children without intellectual disability performed more trials while children with intellectual disability performed fewer trials maintain shorter time in both gross and fine motor tasks [21]. Motor competence of children with intellectual disability tended to select a large number of external attributors which may adversely effect on low self-esteem [20].

Fine motor skills and gross motor skills [31]

Children with mild intellectual disability overall scored low in motor performance indicating lower level of fine motor skills than gross motor skills.

Motor skills learning and children with intellectual disability

Generally, the combination of mental and physical practice were the most effective practice conditions [16, 22, 23, 24, 26, 27, 28]. The summary of feedback (e.g., knowledge of feedback at after every 5th trials vs. feedback after every trial) given were better for children's motor performance in reviewed studies [24, 32].

Many of the reviewed studies interrelated and systematically examined to see the effects of different practice conditions regarding motor skills learning of children with intellectual disability [22, 23, 24, 26, 27, 28].

Children with intellectual disability in random practice group significantly performed with less error than blocked practice group at both transfer and retention phases [22]. Three groups were divided into differently format for practice: (a) variable practice group (60 trials across 4 different kicking environment such as variation of terrains and sequence/order as well), (b) constant practice (60 trials: gradually demanding tasks given), and (c) control group (equal number of trials of the tasks). Variable practice group made more errors during practice but showed good results. In all groups, error reduced once trial repeated (trial block). All groups received 10 transfer trials: ball kicking individually against target / quiet place to prevent distractions. The measurement was based on product outcome by pointing success of performance and no points for failure of performance.

Random practice which provided greater contextual interference were the most effective for transferring and maintaining gross motor skills learning in bean bag tossing tasks [23]. Boys made less errors both on retentions and transfer phases in the studies. Children were assigned randomly into blocked (each weight for twelve blocked with four trials), serial (practice with weight increase in sequence), or random practice condition and performed 48 trials with variations of bean bag weight (four different bean bag weight). Random condition made less error when transferring and retention phases.

Based on the findings of the previous studies [22, 23], the authors examined marginal support of contextual interference effects on gross motor skill learning over 2-day period [24]. Previous study [23] had 2-day retention phase. The results indicated that random practice group showed significantly less error.

Imaginary practice were effective in improving for both cognitive and motor oriented task [27]. Catch trials were given for preparation. Imaginary practice can be a strategy to improve motor skill performance while more factors should be investigated depending on varying tasks in terms of cognition loading across diverse areas. *The use of imaginary task practice for enhancing motor performances were effective while there were no differences between higher and lower cognitive loading of the tasks* [28].

Based on the previous studies which examined the effects of imaginary practice conditions on motor skills performance [27, 28]. From a methodological standpoint, the study improves data trustworthiness by calculating a power (.89) to get appropriate sample size as well as conducting a pre-test to evaluate motor performance of study participants in order to assigned them randomly into different practice conditions. Conclusively, imaginary practice condition was effective to enhance motor skills learning in both low and high cognitive loading tasks (which extended the results of the study # 28).

4. Discussion and Conclusion

The purpose of current literature review is to synthesize the results of studies regarding motor skill learning of children with intellectual disability. Research have been conducted for a long-time regarding motor skill and population with intellectual disability, thus, there is a need for extending comprehensive understanding by synthesizing research findings what is already known based on this literature review and literature reviews in the past years.

Several literature reviews were conducted before this review targeting population with intellectual disability. Rarick (1973) reviewed motor performance of children with intellectual disability in his book chapter based on research findings published from 1930s [35]. His review covered early intervention. In his review, children with intellectual disability indicated (a) lower motor performance level compared to general population of the same gender and age group in both fine and gross motor skills which attributed both from environmental and intellectual deficit, (b) with prompts including assistance and extended time, children with intellectual disability achieved substantial degree of motor skills. However, he cited a national survey at that time, and he pointed out public school system having no organized physical education class for children with mild intellectual disability indicating 25% engaged in 1 hour or more instruction per week. Additionally, Rarick (1973) found (a) positive relationship between conceptual reactions and cognitive motor training, (b) the importance of more opportunities to experience successful performance in physical activities in that academic achievement have been attributed to attitudinal changes, and (c) compared to typically developing children, children with intellectual disability indicated lower physical fitness level and lack of physical activity. The author pointed out poor level of physical growth could be attributed to inappropriate physical activity. Furthermore, lack of school physical education and teachers who have appropriate knowledge for this population and therefore the importance of more qualified programs and ample opportunities for them than general population.

The findings in this literature review were consistent with implications of review by Rarick (1973); (a) lower performance level compared typically developing children in both fine and gross motor skills, and (b) motor skills learning depending on instruction contingencies, time scheduling. And reviewed studies extended this view by specifically focusing on several factors in their studies (e.g., the study regarding knowledge of feedback (d), movement time and reaction time [8, 9].

There are other two reviews regarding motor skills learning and people with intellectual disability. Hoover and Wade (1985) conducted literature review with respect to motor learning and individuals with intellectual disability from a historical context since 1900 [36]. They found two broad traditions as service delivery (problem solving) and explanatory research. They pointed out the information gain models in these two tradition have three problems (a) regardless of research findings as well as information about processing/network investigated 'how learning could be occurred', the problems is attributed to individuals with intellectual disability if they will manifest deficits, (b) study should considered more beyond studying 'organismic capacity-oriented defects in learners', and there is a need to examine the difference of control variables between individuals with and without intellectual disability, and the decision regarding change about task demands, and (c) ambiguity regarding information of process (Hoover & Wade, 1985). Conclusively, the authors indicated incomplete description of the relationship between general psychological theorizing, motor learning and intellectual disability and indicated further study should be conducted with appropriate use of motor control perspectives. They implied knowledge of results based on research and variations in s-r (stimulus and response) could be implemented into training and practical situations.

Block (1991) published a literature review regarding motor development of children with Down Syndrome [37]. The author tried to cover and synthesize research findings over 30 years with connecting to previous reviews. The results indicated (a) unique pattern of motor problems which could attributed to physical characteristics such as hypotonia, reflex development, instability, and obesity, and (b) medical and health problems such as heart defects, atlantoaxial instability and joint hypermobility and sensory-motor problems and their influences on motor development. And those results indicated variability both within the child and more children with Down syndrome. As Hoover and Wade (1985) explained, there should be studies to examine (a) what factors to manifest deficits, and (b) individual aspect and environmental stimuli including controlling variables to determine the differences of individuals with and without intellectual disability. Also, in these reviewed studies, there were consistent results regarding unique pattern of children with Down syndrome as Block (1991) suggested (e.g. the delay of reaction time and large intra-subjects variability in performance). Block (1991) indicated motor characteristics of Down syndrome due to physical characteristics such as hypotonia or reflex. However, when performing basic motor skills, different results could not be attributed to those characteristics. Also, study regarding intellectual disability should include population with Down syndrome because of large number of intellectual disability population including Down syndrome.

5. Conclusion and Implications

Except two studies (single subject research; 32, & 34),

twenty-two studies (11~31, & 33) were conducted based on quantitative research method with cross-sectional design, and merely one study examined based on longitudinal approach. With the use of longitudinal approach, research would provide meaningful data for understanding how motor skills learning could be enhanced and facilitated.

There are variability regarding the use of instrumentations in the reviewed studies, several studies [12, 13, 15, 25, 29, 30, 31] used widely accepted tools (e.g., TGMD-2, MABC, BOTMP, and survey for perceived competence on gross motor skill). Many of the reviewed studies employed specially considered tasks to investigate the effects of intervention by the authors. In each study, all the procedures were specifically described to ensure data trustworthiness. However, the use of more statistical analysis/consideration in terms of reliability should be considered (e.g., pretest of motor skill learning and random assignment of study populations into different practice condition groups, consideration of appropriate number of trials/frequencies for practice conditions along with statistical method before implementing treatment conditions, the use of more extended retention/maintenance periods adding based on the previous studies).

Additionally, depending on the characteristics of instrument/method for measuring motor skills, it would provide process or product-based measures/outcomes only. To enhance trustworthiness of the data in the study, the use of multiple instruments to capture process and product could be considered simultaneously (e.g., improvement of concurrent validity). In terms of population, there are variability among studies regarding age, gender, sampling method, and the level of intellectual disability. In some sense, it is difficult to generalize the findings based on this review, however, study findings and suggestions in each study could be regarded as meaningful information with careful interpretation. And the future study could be conducted in more various settings to cover the limitations due to lack of studies targeting population with intellectual disability. Furthermore, there were few studies including specific demographic information, thus, more contextual information of study populations such as ethnicity and race, and social economic status could be included in the future study.

Based on reviewed studies, future research should conduct to reduce gaps between studies. Regarding the studies which examined different practice conditions on motor skill learning of children with intellectual disability, the findings were systematically interrelated providing valuable information. To make up the limitations, the followings are suggestions which should be considered in the future research. All the procedures in the most studies were detailed explained, however, the following suggestions will be expected to give more insightful understanding to examine motor skills learning of children with intellectual disability.

- The instruction during intervention how guide study participants should be fully monitored to enhance trustworthiness of the study. Furthermore, how the practice is organized could potentially influence on the results.
- Standardized tests also could be considered in terms of validity and reliability of the data.
- Both process and product measures on motor skill learning could provide a comprehensive understanding. To characterize how learning could be facilitated by capturing all the factors to see what is going on during the study will be crucial. For instance, in the study [22], constant practice will be more consistent way to reduce errors while variable practice conditions will be better to transfer skill. Extended periods should be included to examine such inconsistent results to find connections or key factors. And different activities could yield different results. Therefore, studies should be conducted across diverse activities. Regarding practice conditions, more extended periods would be expected due to variability of practice given with related to study periods.
- In terms of research design, merely one study conducted with long term perspective [18, 19]. To fully understand mechanism of motor skill learning of children with intellectual disability, more studies should consider longitudinal methods. Furthermore, many of the studies commonly indicated that the limitations of study findings due to lack of study sample number. Also, the limitations such as the lack of information of children' previous experience could be discussed in the future study.
- Most studies differently organized measurement conditions with variations of frequency and trials. More study should address how much enough practice trials would be provided. Especially, extended practice phases should be provided with considerations of more extended retention phases, [13] the number of trials or additional session would yield different outcome.

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