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Fundamental Movements Investigation of Children with Specific Learning Disorder Based on Multivariate Variance Analysis

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Abstract

Background and objective: The motor is the base of learning and mental processes. This shows the importance of motor impairment in people with specific learning disorder. The purpose of this study is to compare the grasping, pulling& releasing movements in children with specific learning disorder with normal children. **Materials and Methods:** The present study is descriptive, casual comparative (post facto), in terms of its methodology. The study population includes all elementary school students in Tehran, studying in the academic year of 2014-15. A sample of 40 children with specific learning disorder and 40 normal children is selected using available sampling method. Subjects are homogenized in terms of age and grade. Then the researcher-made test of fundamental movement is administered on them. Data are analyzed using multivariate analysis of variance. **Results:** The findings show a significant difference in the grasping, pulling& releasing movements between two groups. According to the findings, it can be concluded that the grasping, pulling& releasing movements of children with specific learning disorder are defective compared to normal children. **Conclusion:** The first behavioral response of the child is a type of movement that is significant in the learning process. The fundamental movements of children with specific learning disorder are much different from that of normal children, the rehabilitation of which can improve the focus and attention of these children. Findings of the present study can be useful to psychologists, families and schools.

Keywords: grasping, pulling, releasing, specific learning disorder

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1. Introduction

Transformation is a process through which a person changes between the intervals of life in a number of components, such as the cognitive, sensory, linguistic, social and physical components. Some of these changes are obvious, such as the growth of language and movement, and some of these changes are less visible. The field of motion is one of the areas where changes are often prominent and evident, especially in the early years when motor responses are the primary activity of children [1]. The motor skill plays an important role in the active discovery of the baby's environment, and through this practice, the baby shapes his knowledge of the world around him. Movement, as the exclusive language of the first year of life, is important and remains the basis of communication throughout life. At present, cognitive neuroscientists believe that the ability to understand others depends on the ability to coordinate visual information with the tacit knowledge of movement [2].

Our mental processes are shaped by our bodies and a variety of motor-perceptual experiences that are the product of moving in the surrounding world and interacting with it. This view, in general, is called embodied cognition, and a version of this history that is specifically designated to language is known as embodied meanings [2]. Piaget takes into account the sensory-motor skills in the early stages of childhood development as a major factor in early cognitive development [3, 4]. Other researchers also agree that initial motor activity is essential for stimulating the nervous system and brain development, and that there is a correlation between motor and cognitive regions [5]. For example, the cerebellum is effective both in motor and cognitive activities, and the prefrontal cortex plays an important role both in cognitive and motor activities, and the ineffectiveness of these parts or neurological pathways leads to cognitive and motor problems together [6].

In childhood, the child's perception of the environment changes with the ability to sit, crawl, and finally stand up, and the range of learning and information increases [7]. Longitudinal studies show that children who are deficient in motor development stages show problems in cognitive and learning skills at older ages [8 and 9]. One of the disabilities in childhood, one of the symptoms of which is motor problems, is specific learning disorder. Specific learning disorder is revealed as learning difficulties in acquiring age-related skills in early school years. These problems last for at least 6 months and are not related to mental disabilities and developmental or neurological impairments. These problems include disorder in reading and writing, and mathematical calculations [10]. In the fifth edition of Diagnostic and Statistical Manual of Mental Disorders, learning disability is changed to learning disorder and reading disorder, writing disorder, and mathematical disorder are known as a characteristic for specific learning disorder [11-13].

Blythe and Hyland [14] investigated the developmental history of 72 children with learning disabilities in comparison to normal children. The results showed that there was a significant difference between the two groups' developmental history. Delay in walking and speaking was significantly higher in children with learning disabilities. Son and Meisels [3] investigated the relationship between motor skills in the early years and academic achievement in reading and mathematics at the first grade of primary school. The results showed that visual-motor skills significantly predict academic achievement in the coming years, and deficiency in this skill can be considered as a risk factor for identifying academic failure in the following years.

About 55% of children with specific learning disabilities also have developmental coordination impairment [15]. It is still unclear what different and similar patterns of defects in children are associated with the comorbidity diagnosis of specific learning disorder and developmental coordination impairment, but research suggests that children with comorbidity abnormalities (specific learning disorder and developmental coordination disorder) are lower in equilibrium and speed assignments than children with developmental coordination disorder [16]. Various studies have shown that children with specific learning disorder have had interruptions in their motor developmental stages. Fine and great motor skills of these children are lower in comparison with their normal peers, but the diagnosis and treatment in the area of learning problems are more directed towards the removal of syndrome and the focus is on learning resources and more practice of reading, writing, spelling and math, and repetition of exercises. But it is more useful to look at the problem in an underlying way, and the fundamental physical skills of these abilities can be evaluated and cured for early prediction [17].

The process of diagnosing specific learning disabilities is often postponed from mid-to-late-school, and students often experience a period of learning failure before receiving special services [16], while early diagnosis and interventions are very important because the positive effects of treatment are much more difficult and costly when children grow older [18]. Studies show that in the process of diagnosing specific learning disabilities, emphasis is placed on academic skills and IQ estimates. This is while pre-primary schooling skills are not so wide-ranging that they accurately predict learning problems in the years to come and focusing on the educational agent causes other crucial aspects of childhood development that may affect the diagnosis of learning disabilities to be ignored [20].

There are a number of prerequisite skills that could predict future academic achievement in different areas. Phonological processing, naming speed, memory, motor function and lateral superiority predict a person’s ability to read and spell in subsequent years [21]. Many studies have shown that malfunctioning of academic skills are associated with malfunctioning of motor skills, there is a relationship between motor skills and academic achievement in later years, and motor skills can improve academic achievement in all areas of reading, spelling and mathematics [3].

Considering the deficiency of children with learning disabilities in motor skills and considering the importance of early diagnosis of children with learning disabilities, there has not been a study on the progression of these fundamental movements in these children. On the basis of motion interactions, Flanagan and Alfanso [22] emphasize the motor aspect of the initial relationship, which can result in the development of complicated actions necessary for thinking or blocking such a transformation.

These movements appear to be fundamental movements and movement tendencies in the first year of life and play a key role in all human interaction and learning throughout life. Therefore, identifying and treating interactive and learning problems rooted in neonatal period can be done with the use of the roles of these movements in shaping relationships. Considering the role of fundamental movements in motor evolution and neuropsychiatric development, it is necessary to carry out further research and studies in this regard. Therefore, the present study attempts to address this need by doing so.

2. Materials and methods

The present study was descriptive, casual comparative (post facto), in terms of its methodology. The study population included all second to fourth grade elementary school students in Tehran, studying in the academic year of 2014-15. A sample of 40 children with specific learning disorder and 40 normal children was selected using available sampling method. Subjects were homogenized in terms of age and grade.

In this research, a researcher-made checklist was used to examine the children's fundamental movements. The checklist included six fundamental motions. To create the checklist, the researcher analyzed the movements into components according to the books and articles in the field of fundamental movements, and the researcher and three other specialists reviewed the recorded movements of two children.

After reviewing the motions, suggestions and revisions were presented for a closer look. After correction and review of the checklist, the researcher and specialists reviewed two other children, which included minor amendments to the questionnaire at this stage. After amendments, the validity of the questionnaire was confirmed by experts. Scoring items of fundamental movements is yes, no, and to some extent. To facilitate scoring, items of each section are defined in the log.

Two reliability estimation methods were used to obtain the reliability of each of the movement dimensions. In the first method of reliability, using the Cronbach's alpha coefficient, the internal consistency (reliability) of each movement dimension was investigated. Because questions related to the 6 movement dimensions were evaluated by four different judges, it was attempted to calculate the alpha coefficient separately for each movement dimensions for each of the assessors. The results of calculations for the coefficients of reliability (Cronbach's alpha) are shown in Table [1].

Table 1: Cronbach's alpha coefficient for each dimension of fundamental movement

Dimension	Number of questions	Assessor			
		First	Second	Third	Fourth
Grasping	6	0.960	0.962	0.966	0.965
Pulling	8	0.750	0.704	0.720	0.714
Releasing	4	0.924	0.916	0.932	0.929

Table (1) shows that the reliability coefficients for the movement dimensions are high and acceptable. In other words, the coefficient of internal consistency between questions related to each dimension is of an acceptable and high value. A look at Table (1) suggests that the reliability values for each assessor are very close and similar. The result is that a combination and average score for each dimension can be obtained by taking the average score of 4 judges. Kappa coefficient was used to assess the agreement between evaluators. The result of the statistical analysis showed that Kapa coefficient for assessing the agreement between evaluators is 0.93 to 0.97, which indicates a very high agreement between evaluators.

2.1. Cronbach's alpha

Cronbach's alpha is a measure used to assess the reliability, or internal consistency, of a set of scale or test items. In other words, the reliability of any given measurement refers to the extent to which it is a consistent measure of a concept, and Cronbach's alpha is one way of measuring the strength of that consistency [23].

Cronbach's alpha is computed by correlating the score for each scale item with the total score for each observation (usually individual survey respondents or test takers), and then comparing that to the variance for all individual item scores [23]:

$$\alpha = \left(\frac{k}{k-1}\right)\left(1-\frac{\sum_{i=1}^{k}\sigma_{y_i}^2}{\sigma_x^2}\right) \tag{2-1}$$

…where: k refers to the number of scale items

$\sigma_{y_i}^2$ refers to the variance associated with item i

σ_x^2 refers to the variance associated with the observed total scores

Alternatively, Cronbach's alpha can also be defined as:

$$\alpha = \frac{k \times \bar{c}}{\bar{v} + (k-1)\bar{c}} \quad (2\text{-}2)$$

…where: k refers to the number of scale items

$\bar{c}$ refers to the average of all covariances between items

$\bar{v}$ refers to the average variance of each item

Cronbach's alpha is thus a function of the number of items in a test, the average covariance between pairs of items, and the variance of the total score [23].

3. Findings

Table 2: descriptive comparisons of the scores of two groups of control and specific learning disorder in fundamental movements

Type of movement	Group	Mean	SD	SD error
Grasping	Specific learning disorder	0.15	0.144	0.022
	Control	0.97	0.035	0.0055
Pulling	Specific learning disorder	0.14	0.13	0.020
	Control	0.92	0.063	0.010
Releasing	Specific learning disorder	0.098	0.084	0.013
	Control	0.91	0.099	0.015

Based on the findings of Table 2, in all types of movements, children with a specific learning disorder had lower scores than normal children. Multi-way analysis of variance was used to determine whether this difference was significant between the two groups. Prior to multi-way analysis of variance, the main assumptions of multi-way analysis of variance were examined.

Box test was used to verify the variance-covariance matrix similarity, homogeneity of regression coefficients, Kolmogorov-Smirnov test was used to verify the assumption of the normality of the data and Levin test was used to test the assumptions of homogeneity of variances.

Results showed that the significance level in these tests was more than 0.05 and the analysis of variance can be done.

Table 3: results of MANOVA's significant test on fundamental movements in two groups

Lambda Wilkes	Value	F	Df	Error of df	P	Eta
Group	0.07	1758.026	6	73	0.001	0.993

Based on the data observed in Table 3, the effect of the group on the linear composition of the dependent variables is significant. For this reason, multivariate analysis of variance has been used to determine the effect of which dependent variable is significant. The results are presented in Table (4).

3.1. MANOVA

MANOVA can be introduced as the obvious generalization of the analysis of variance (ANOVA) from a single to several outcome variables.

3.1.1. Fundamental equation for MANOVA:

First, the total sum-of-squares is partitioned into the sum-of-squares between groups (SS_{bg}) and the sum-of-squares within groups (SS_{wg}) [24]:

$$SS_{tot} = SS_{bg} + SS_{wg} \tag{3-1}$$

This can be expressed as:

$$\sum_i \sum_j \left(Y_{ij} - GM\right)^2 = n\sum_j \left(\bar{Y}_j - GM\right)^2 + \sum_i \sum_j \left(Y_{ij} - \bar{Y}_{ij}\right)^2 \tag{3-2}$$

The SSbg is then partitioned into variance for each IV and the interactions between them.

In a case where there are two IVs (IV1 and IV2), the equation looks like this [24]:

$$\begin{aligned} n_{km}\sum_k \sum_m (IV1IV2_{km} - GM)^2 &= n_k \sum_k (IV1_k - GM)^2 + n_m \sum_m (IV2_m - GM)^2 + \\ &\left[n_{km}\sum_k \sum_m (IV1IV2_{km} - GM)^2 - n_k \sum_k (IV1_k - GM)^2 - n_m \sum_m (IV2_m - GM)^2\right] \end{aligned} \tag{3-3}$$

Therefore, the complete equation becomes:

$$\begin{aligned} \sum_i \sum_k \sum_m (Y_{ikm} - GM)^2 &= n_k \sum_k (IV1_k - GM)^2 + n_m \sum_m (IV2_m - GM)^2 + \\ &\left[n_{km}\sum_k \sum_m (IV1IV2_{km} - GM)^2 - n_k \sum_k (IV1_k - GM)^2 - n_m \sum_m (IV2_m - GM)^2\right] \\ &+ \sum_i \sum_k \sum_m (Y_{ikm} - IV1IV2_{km})^2 \end{aligned} \tag{3-4}$$

Because in MANOVA there are multiple DVs, a column matrix (vector) of values for each DV is used. For two DVs (a and b) with n values, this can be represented [23]:

$$Y_{i...n} = \begin{bmatrix} a1 \\ b1 \end{bmatrix} \begin{bmatrix} a2 \\ b2 \end{bmatrix} \begin{bmatrix} a3 \\ b3 \end{bmatrix} \cdots \begin{bmatrix} a_n \\ b_n \end{bmatrix} \tag{3-5}$$

Similarly, there are column matrices for IVs - one matrix for each level of every IV. Each matrix of IVs for each level is composed of means for every DV. For "n" DVs and "m" levels of each IV, this is written [23]:

$$IVA_1 = \begin{bmatrix} \overline{DV}_1 \\ \vdots \\ \overline{DV_n} \end{bmatrix} IVA_2 = \begin{bmatrix} \overline{DV}_1 \\ \vdots \\ \overline{DV_n} \end{bmatrix} \ldots IVA_m \begin{bmatrix} \overline{DV}_1 \\ \vdots \\ \overline{DV_n} \end{bmatrix} \tag{3-6}$$

Additional matrices are calculated for cell means averaged over the individuals in each group.

Finally, a single matrix of grand means is calculated with one value for each DV averaged across all individuals in matrix [24].

$$GM = \begin{bmatrix} DV_1 \\ \vdots \\ DV_n \end{bmatrix} \tag{3-7}$$

Differences are found by subtracting one matrix from another to produce new matrices. From these new matrices the error term is found by subtracting the GM matrix from each of the DV individual scores:

$$(Y_{ikm} - GM) \tag{3-8}$$

Next, each column matrix is multiplied by each row matrix:

$$(Y_{ikm} - GM)(Y_{ikm} - GM)' \tag{3-9}$$

These matrices are summed over rows and groups, just as squared differences are summed in ANOVA. The result is an S matrix (also known as: "sum-of-squares and cross-products," "cross-products," or "sum-of-products" matrices). [24]

For a two IV, two DV example:

$$\sum_i\sum_k\sum_m (Y_{ikm}-GM)(Y_{ikm}-GM)' = n_k\sum_k (IV1_k-GM)(IV1_k-GM)' +$$
$$n_m\sum_m (IV2_m-GM)(IV2_m-GM)' + [\ n_{km}\sum_k\sum_m (IV1IV2_{km}-GM)(IV1IV2_{km}-GM)' -$$
$$n_k\sum_k (IV1_k-GM)(IV1_k-GM)' - n_m\sum_m (IV2_m-GM)(IV2_m-GM)\ ]+ \qquad (3\text{-}10)$$
$$\sum_i\sum_k\sum_m (Y_{ikm}-IV1IV2_{km})(Y_{ikm}-IV1IV2_{km})'$$

Stot = SIV1 + SIV2 + Sinteraction + Swithin-group error (3-11)

Determinants (variance) of the S matrices are found. Wilks' λ is the test statistic preferred for MANOVA, and is found through a ratio of the determinants:

$$\Lambda = \frac{|S_{error}|}{|S_{effect}+S_{error}|} \qquad (3\text{-}12)$$

An estimate of F can be calculated through the following equations:

$$F_{approximate}(df_1, df_2) = \left(\frac{1-y}{y}\right)\left(\frac{df_2}{df_1}\right) \qquad (3\text{-}13)$$

Where,

$$df_1 = p(df_{effect})\quad df_2 = s\left[(df_{error}) - \frac{p-df_{effect}+1}{2}\right] - \left[\frac{p(df_{effect})-2}{2}\right]\quad s = \sqrt{\frac{p^2(df_{effect})^2-4}{p^2+(df_{effect})^2-5}} \qquad (3\text{-}14)$$

$$y = \Lambda^{1/s}\quad p = No.ofDVs\quad df_{effect} = (IV1-1)(IV2-1)\ldots(IVn-1)\quad df_{error} = n_{I1} * n_{I2}(n_{DV}-1) \qquad (3\text{-}15)$$

Finally, we need to measure the strength of the association. Since Wilks' λ is equal to the variance not accounted for by the combined DVs, then (1 – λ) is the variance that is accounted for by the best linear combination of DVs[24].

$$\eta^2 = 1 - \Lambda \qquad (3\text{-}16)$$

However, because this is summed across all DVs, it can be greater than one and therefore less useful than [23]:

$$\eta^2 = 1 - \Lambda^{\frac{1}{s}} \tag{3-17}$$

Other statistics can be calculated in addition to Wilks' λ. The following is a short list of some of the popularly reported test statistics for MANOVA:

- Wilks' λ = pooled ratio of error variances to effect variance plus error variance
    - This is the most commonly reported test statistic, but not always the best choice.
    - Gives an exact F-statistic

- Hotelling's trace = pooled ratio of effect variance to error variance

$$T = \sum_{i=1}^{s} \lambda_i \tag{3-18}$$

- Pillai-Bartlett criterion = pooled effect variances
- Often considered most robust and powerful test statistic.
- Gives most conservative F-statistic.

$$V = \sum_{i=1}^{s} \frac{\lambda_i}{1+\lambda_i} \tag{3-19}$$

- Roy's Largest Root = largest eigenvalue
    - Gives an upper-bound of the F-statistic.
    - Disregard if none of the other test statistics are significant.

MANOVA works well in situations where there are moderate correlations between DVs.

Table 4: results of multivariate analysis of variance for comparison of fundamental movements in two groups (children with specific learning disabilities and normal children)

Source	Group	Sum of squares	Df	Mean of squares	F ratio	Sig. level	Eta
Fundamental movements	Grasping	13.424	1	13.42	1220.65	0.001	0.94
	Pulling	12.170	1	12.17	1160.76	0.001	0.93
	Releasing	13.20	1	13.20	1546.93	0.001	0.95

The results of Table 4 show that there is a significant difference between the two groups of children with specific learning disorder and control in all of the fundamental movements. That is, normal children get higher scores than children with learning disabilities.

Table 5 shows the difference between the mean and other statistical indices in order to examine the differences between the two groups in the fundamental movements for greater clarity of the results of the study.

Table 5: Differences between the two control and learning disorder groups

Dependent variable	Group I	Group J	Mean difference (I-J)	Error of SD	Sig. level
Grasping	Control	Control	-0.82*	0.016	0.001
	Specific learning disorder	Specific learning disorder	-0.81*	0.023	0.001
Pulling	Control	Control	-0.81*	0.023	0.001
	Specific learning disorder	Specific learning disorder	-0.78*	0.023	0.001
Releasing	Control	Control	-0.78*	0.023	0.001
	Specific learning disorder	Specific learning disorder	-0.81*	0.021	0.001
	Control	Control	-0.81*	0.021	0.001

4. Discussion

The findings showed that fundamental movements of children with a specific learning disorder are defective in comparison with normal children. So far, research has not been done on the examination of fundamental movements of children with learning disabilities. Movements play an important role in physical growth and enhancement of brain neural network and actually make the brain. Unplanned motor communication is the gateway to opportunities. These opportunities are important for the formation of large motor skills from birth to age five and learning high-level skills [5]. The evolution of movements acts as a control parameter for subsequent transformation and is the prerequisite for other transformative functions, such as cognitive, linguistic and social abilities [25]. In studies, much attention has been paid to the role of motor growth in the development of language, excitement and cognition [26]. Studies show that there is a relationship between childhood motor skills and language ability, displaying gestures, and vocabulary of older ages [24-26]. Other studies also show that there is a relationship between the level of motor skills of young children and their participation in social play, positive interaction with their mothers, and the level of depression and anxiety in older ages [31 , 32]. Regarding the relationship between movement and cognitive skills, studies also show that motor skills deficiency over the years of growth can predict a defect in cognitive skills at older ages [33]. Children who have progressed stages of motor development without interruption have better performance in working memory and performance classifications than those with interruptions [34], and their motor skills in childhood are a good predictor of working memory and the processing speed of information at an older age [35].

One of the disorders of evolution period that the study of motion can play an important role in its predicting and recognizing is specific learning disorder [35]. Studies have shown that growth indicators in the area of development of motor, cognitive, linguistic and social skills are helpful in early prediction and diagnosis of specific learning disorder [37].

Berninger et al. [36] studied predictors of children's handwriting, spelling and writing. The results of this study showed that the best predictor of these skills is phonological awareness, written coding, ability to represent written words, motor planning for consecutive movement of fingers, and control of motor outputs. Studies also show that children with a specific learning disorder have obvious defects in motor skills such as licking, jumping, grasping and releasing balls, biking, gymnastics coordination, swimming, and navigation problems such as saying right and left and defects in subtle muscle skills including problems with closing a shoelace, closing the button, and using the writing tools [36].

The first stages of childhood development are through movement and contact with the environment. Children use their movements of grasping, pulling, and releasing to tell their wishes and needs to parents and the environment. The fundamental movements are formed in the first year of life and in relation to the environment, they are present throughout all life-long activities, and children's motor development can be examined by observing and examining them during the course of the development [39].

Studies show that the method of learning fundamental movements affects the evolution, cognition, social skills, and personality in later periods [40]. These movement patterns are the basis of all movements that can be explored both in childhood and in adulthood. Watching the fundamental movements of adults and children gives us information about their organizational capacity during the evolution. When therapists look at movement from the developmental perspective, they can break down the fundamental movements into sub-items and evaluate, diagnose and treat by observing the child [2]. An analytical study of fundamental movements has been investigated in the treatment of disorders such as depression and behavioral disorder (case study) [39]. The present study showed that children with a specific learning disorder are defective in fundamental movements.

In the fundamental movement of grasping and pulling, the child communicates with the environment through ears and vitality. In grasping, the person steadfastly finds out what he is grasping and combining what he has received in pulling. In grasping and pulling, part of the body goes to the surrounding area, while the rest of the body is drawn [42]. It grasping and pulling, the child gets information from the surrounding environment, keeps it, has constant communication, and integrates the information and owns it. Many children with learning disorder have difficulties in maintaining information and using the strategies to integrate information with personal knowledge, which can be due to difficulty in grasping and pulling.

With the completion of pulling, releasing can be followed. Releasing a kept object helps the child go to a new task and experiences lack of organization and reorganization. The movement of releasing in adulthood may appear in emotional and physical non-organization and reorganization, when one abandons what has ended, or in another way feels that he has to ignore his current interest in the design of the next activity and experiences some sort of deterrence [39]. Many children with learning disorder have difficulty in cognitive deterrence and cannot ignore the attention to current stimuli in favor of secondary stimuli and amplifiers and plan long-term goals. Failure in the movement of releasing can be one of the causes of the weakness in the cognitive deterrence of these children.

5. Conclusion

So far, research has not been done on the examination of fundamental movements of children with specific learning disorder, among whom deficiency in motor skills is one of the characteristics of these children. In this study, fundamental movements of children with specific learning disorder were studied. The results of the study showed that children with a specific learning disorder, in comparison with normal children, had significant deficiency in grasping, pulling, and releasing. Studies show that all conditions associated with survival, sucking, swallowing and breathing require fundamental movements [43]. Case studies also show that any interruption and difficulty in these fundamental movements can lead to motor problems, imbalances in the body, and problems with perception, sequence, organization, memory, and creativity [41]. These fundamental movements can be studied in the first years of life and before the primary school age, and one can study the movements in the present to predict the past and future problems. Therefore, the defect in the fundamental movements of children with specific learning disorder, who also experience defects in the cognitive and motor skills, can indicate a similar pattern of pre-primary and lower-grade impairment. Therefore, considering the possibility of examining and analyzing the fundamental movements of preschoolers, the presence of malfunctioning in the pre-primary ages can predict specific learning disorder. Accordingly, it is suggested to use findings of this study for early prediction of specific learning disorder. Also, motor mobility interventions based on fundamental movements and motor tendencies can be designed for children with specific learning disorder.

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