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## **Gross motor skills in children with cerebral palsy and intellectual disability**

**Objectives:** The aim of this study is to determine the connection of gross motor skills (locomotor skills and object control) and the degree of associated intellectual disability (ID) in children with cerebral palsy (CP).

**Participants and methods:** The study sample included 54 children with CP and associated ID age 5 years to 6 years and 11 months. For the assessment of tested skills, The Gross Motor Function Classification System-Expanded and Revised (GMFCS-E&R), Wechsler Preschool and Primary Scale of Intelligence-Fourth Edition (WPPSI-IV) and Test of Gross Motor Development Second Edition (TGMD-2) were used.

**Results:** The results of this study indicate better quality of locomotor skills than object control skills in children with CP and associated ID. Children with CP and mild ID have better quality of locomotor skills and object control, than children with CP and moderate ID. Differences between these two groups of children are presented relative to GMFCS-E&R levels.

**Conclusion:** This study has determined significant interconnection of the quality of gross motor functions and intellectual capacity in preschool children with CP. This should be considered when creating more detailed individual developmental rehabilitation plan in children with CP and associated ID and predict adequate measures of developmental stimulation.

**Key words:** Locomotor skills; object control; cerebral paralysis; intellectual disability

Cerebral palsy (CP) is a set of symptoms that are clinically manifested as disorders of body position and movement, muscle tone, coordination and balance. They occur as a result of non-progressive brain damage during the intrauterine period, at birth, or in the first years

of life.<sup>[1]</sup> Motor disorders in CP are mainly accompanied by a number of other problems such as cognitive impairment, sensory and perceptual problems, communication problems, epilepsy.<sup>[2]</sup> A large number of children with CP have some type of cognitive delay.<sup>[3]</sup> It is estimated that 40% to 65% of children with CP have intellectual disability (ID).<sup>[4,5]</sup> Studies show that the intellectual capacity of children with CP is lower than in the typical population. Also, more severe motor impairments within CP are associated with a greater degree of intellectual dysfunction.<sup>[5]</sup> Children with spastic type of CP have highest tendency for ID.<sup>[4]</sup>

Children with CP very often show difficulties in performing complex motor tasks.<sup>[6]</sup>

Gross motor skills are considered to be the basis for the development of motor skills.<sup>[7]</sup> They represent the ability to produce movements of the arms, legs, or body with some control.<sup>[8]</sup> They consist of two subgroups: locomotor skills and object control skills.<sup>[7]</sup> Locomotor skills carry the body through space and refer to general movements, while object control skills include projecting or manipulation of an object.<sup>[9,10]</sup>

Determining the functional level of these abilities is very important in order for children with CP and associated ID to maximize their gross motor skills in daily activities.<sup>[11]</sup> It is especially important to make a thorough assessment during the kindergarten years that precede school.<sup>[12]</sup> Thus, the goals of habilitation and the planning of the individual rehabilitation program will be properly managed. Accurate identification of dysfunction in one of the components of motor skill can be recorded in the treatment plan and used to improve performance in the zone of proximal development.

Until now, previous studies mainly included children with CP without ID when examining gross motor skills,<sup>[13,14]</sup> or children with ID without CP,<sup>[15,16]</sup> while there are a small number of studies involving both parameters associated.<sup>[5]</sup> These deficiencies have also been detected in recent studies.<sup>[17]</sup>

This study focused on the age range 5 to 7 years, the time at which the diagnosis of CP can be reliably confirmed, the ID identified, as well as most other accompanying difficulties.

The purpose of this paper was to examine the quality of gross motor skills assessed in the everyday kindergarten environment of children with CP of varying degrees of ID, after diagnosis and initial clinical follow-up. Providing support in developing mentioned skills in this age is important for later optimal schooling and establishing greater independence of the child with CP and associated ID.

The aim of the research is to determine the connection of gross motor skills (locomotor skills and object control) and the degree of associated ID in children with CP.

## **MATERIAL AND METHODS**

### **Participants**

The study sample included 54 children with CP and associated ID age 5 years to 6 years and 11 months who were monitored clinically by pediatric neurological clinics in XXX from May 2017 to September 2018. The testing itself was conducted from September to November 2018 in regular and special kindergartens in XXX (wider XXX and XXX). Respondents had no surgical intervention and have regularly attended kindergarten, with rare authorized absences.

Inclusive criteria for this study were:

- CP,
- older preschool age,
- ability to walk with or without walking aids,

- mild or moderate ID that allows simple verbal and motor orders to be followed,
- presence of the child in kindergarten in the current enrollment year because of the need for child's familiarity of the testing space and the examiner who collects data.

Exclusive criteria included:

- neurological, neuromotor and neuromuscular diseases, sensory and other medical conditions that limit participation in physical activity, other than CP.

None of the children were on antispastic or anticonvulsant pharmacotherapy (epilepsy was exclusion criterion) at least 6 months prior to enrollment in the study.

Administration office of each kindergarten and parents gave their written consent to include the children in the research, and the children gave their verbal consent before testing. Also, it was explained to parents and children that they could withdraw from participating in the study at any time. The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of the XXX (number 134/2).

## **Measures**

Severity of CP was estimated by The Gross Motor Function Classification System-Expanded and Revised; GMFCS-E&R).<sup>[18,19]</sup> This system is based on voluntarily stimulated movements with an emphasis on sitting, transfers and ability to move. It classifies CP into five levels. Differences between levels are based on functional limitations in everyday activities, need for manual aids (walkers, or crutches/sticks), or for wheelchairs. Differences between level I and level II are not as pronounced as differences between other levels.<sup>[18,19]</sup>

Intellectual level examination was performed by Wechsler Preschool and Primary Scale of Intelligence - Fourth Edition (WPPSI-IV). It is a comprehensive clinical tool designed to assess the cognitive functioning of children age 2 years and 6 months to 7 years and 7 months.<sup>[20]</sup> Severity levels of ID (mild, moderate, severe, profound) are described in

DSM-V. These levels are defined in relation to the required level of support within the frame of adaptive behavior and performing daily living skills. Cognitive deficit was determined by a standardized measure of intelligence, with scores below 70 ( $\pm 5$ ) (two or more SD below the mean of 100 in the average population).<sup>[21]</sup>

Test of Gross Motor Development Second Edition (TGMD-2)<sup>[22]</sup> is the most commonly used standardized instrument for assessing gross motor skills in children age 3 to 10 years.<sup>[15,23]</sup> It is used to identify children who significantly lag behind their peers in gross motor skills development based on criteria.<sup>[22]</sup> This test is making individual planning of the gross motor development program easier to direct, as well as to evaluate individual progress in children with typical development. Research shows that it is valid and reliable for children with CP and children with ID.<sup>[7,13,16]</sup> The test consists of two subtests: Locomotor Skills and Object Control. Raw points are converted to standardized points using norm tables, taking into the account the exact age of the child.<sup>[22]</sup>

## **Procedure**

Same assessment protocol was used for all participants. The CP type and GMFCS-E&R level were determined by the pediatric neurologist at the clinic. Individual examination of intellectual level using WPPSI-IV and DSM-V was performed by a psychologist, also at the clinic. Assessment of gross motor skills of participants with the TGMD-2 was carried out individually in a separate kindergarten room intended for motor exercises.

## **Statistical Analysis**

Statistical analysis was conducted using IBM SPSS version 22.0 software (IBM Corp., Armonk, NY, USA) and Amos (Version 20; SPSS, Inc., Chicago, IL) that were used for descriptive and multigroup factor analyzes, respectively.

Descriptive data are expressed as mean  $\pm$  standard deviation (SD), frequencies, and percentages. The reliability of the instrument used (TGMD-2) was verified by applying the internal consistency coefficient (Kronbach's  $\alpha$ ).  $\chi^2$  was applied for the corresponding comparisons.

Data were tested for normal distribution by the Shapiro-Wilk test. The effect size was calculated using the mean and standard deviation of the groups (ANOVA (squared eta,  $\eta^2$ ) and  $t$ -test (Cohen's  $d$ )). Correlations between variables were analyzed by Spearman's correlation test. A  $p$  value  $<0.05$  was considered statistically significant.

Factor analysis and structural equation modeling were conducted. Model 1 includes testing the factor validity of TGMD-2 using confirmatory factor analysis. In Model 2, the ID disposition was added as a covariate. The marginal results reported in the literature were used as a guideline for good fit models ( $CFI > 0.95$ ,  $RMSEA < 0.06$ ).<sup>[24]</sup>

## RESULTS

The sample included 24 girls (44.4%) and 30 boys (55.6%) age 5 years to 6 years and 11 months ( $5.74 \pm 0.82$ ), all with spastic CP type, 35 children (64.81%) having diplegia, and 19 (35.19%) hemiplegia. The height of the subjects was  $108.3 \pm 6.0$  cm, body mass  $18.1 \pm 3.4$  kg, and body mass index (BMI)  $16.7 \pm 1.2$  kg / m<sup>2</sup>. All included children were classified in the first three GMFCS-E&R levels: I (n=14), II (n=18), III (n=22). The other two levels were not covered by this sample.

According to DSM-V and WPPSI-IV, 28 subjects (51.9%) had mild ID and 26 subjects (48.1%) had moderate ID. No statistically significant differences were found in the distribution between the two groups (mild ID vs. moderate ID) and GMFCS-E&R levels ( $\chi^2 = 2.02$ ,  $df = 2$ ,  $p = 0.364$ ). Respondents of the two groups did not differ in age or in BMI ( $p > 0.05$ ).

Table 1 shows the distribution of the respondents by demographic and clinical characteristic, and Table 2 shows distribution of GMFCS-E&R level and category of ID.

The reliability of the instrument used (TGMD-2) was verified by applying an internal consistency coefficient (Kronbach's  $\alpha$  coefficient ranging from 0.832 to 0.951 for 12 tasks/abilities), indicating that it is a test of high and acceptable reliability.

The mean scores of the items on the two subtests TGMD-2 for children with CP and mild ID for all three levels of GMFCS-E&R are shown in Table 3. It shows significances that are found in total and standardized score. The mutual significances of individual items within the subtests at the aforementioned levels were not considered. The total score was used to detect significance between the GMFCS-E&R levels within each subtest, while a standardized score was used to determine differences between the two subtests for each GMFCS-E&R level. Significant differences between levels were found in total locomotor skill scores ( $F = 58.30$ ;  $p = 0.001$ ;  $\eta^2 = 0.11$ ) and object control ( $F = 72.19$ ;  $p = 0.001$ ;  $\eta^2 = 0.20$ ). Post hoc comparisons using Tukey's HSD test showed that all three levels were mutually different (I > II > III). Subjects of all levels were found to score higher standardized scores on the subtest of Locomotor Skills than standardized scores on the subtest Object Control (I:  $t = 18.118$ ;  $p = 0.001$ ;  $d = 0.185$ ; II:  $t = 13.087$ ;  $p = 0.009$ ;  $d = 0.593$ ; III:  $t = 8.432$ ;  $p = 0.003$ ;  $d = 0.484$ ).

Descriptive values of TGMD-2 scores for children with CP and moderate ID of all three levels of GMFCS-E&R are shown in Table 4. Significant differences between levels



were found in the total scores of locomotor skills ( $F = 12.86$ ;  $p = 0.001$ ;  $\eta^2 = 0.09$ ) and object control ( $F = 3.14$ ;  $p = 0.001$ ;  $\eta^2 = 0.01$ ). Post hoc comparisons using Tukey's HSD test showed that level I was significantly different from the other two, with no statistically significant difference found between second and third level (I > II, III). Level II and level III subjects with moderate ID score higher standard scores on the subtest Locomotor Skills relative to standardized scores on the subtest Object Control (II:  $t = 2.797$ ;  $p = 0.007$ ;  $d = 0.747$ ; III:  $t = 2.643$ ;  $p = 0.010$ ;  $d = 0.922$ ). At level I, difference in the standard scores of the two subtests was not statistically significant (I:  $t = 0.882$ ;  $p = 0.516$ ).

The results of the correlation analysis, shown in Table 5, indicate that there is a correlation between the items in Locomotor Skill and the items in Object Control subtests, in a range from low to high ( $r = 0.23$  to  $r = 0.88$ ).

Two models were verified in the study: Model 1 with first-order correlated factors and Model 2 with introduced covariance.

Model 1 consisted of two latent factors and twelve indicators (manifest variables). Confirmatory factor analysis of the TGMD-2 item with Locomotor Skills and Object Control factors showed a good fit of the model ( $\chi^2 = 236,713$ ,  $df = 53$ ,  $p = 0.001$ ,  $CFI = 0.972$ ,  $RMSEA = 0.040$ ). Factor loadings indicate that most variables have sufficiently high factor weight, at the interval  $\beta \in [0.47, 0.79]$  ( $p < 0.001$ ) for the first and second factor. The two-factor intercorrelation was  $r = 0.73$ ,  $p < 0.001$ . This result confirmed the two-factor structure of TGMD-2, which has been established in other studies. <sup>[16,22,25]</sup>

Model 2, in which the covariant ID was added to Model 1 (Figure 1), achieved a slightly weaker fit of the first model ( $\chi^2 = 317.673$ ,  $df = 98$ ,  $p = 0.001$ ,  $CFI = 0.954$ ,  $RMSEA = 0.044$ ). The degree of ID affects the quality of locomotor skills and the quality of object control skills. The lower level of the ID category, causes the lower the quality of the locomotion and the quality of the object control. Children with CP and mild ID, compared to

children with CP and moderate ID, achieved better performance in locomotion ( $\beta = 0.42, p < 0.001$ ) and object control ( $\beta = 0.61, p < 0.001$ ). The intercorrelation between the two TGMD-2 factors in this model is  $r = 0.71$  ( $p = 0.001$ ).

## DISCUSSION

This study focused on measuring the quality of gross motor skills viewed through locomotor skills and objects control in children with CP and associated mild or moderate ID. The purpose of this assessment was to thoroughly determine the developmental profile of a child with CP and associated ID in the domain of motor skills. Developmental profile represents an integral part of an individual developmental rehabilitation plan that is created and implemented after diagnosis and initial clinical monitoring. [26-28]

The results showed that children with CP, level mild and moderate ID, exhibit different difficulties in performing the motor tasks given under TGMD-2.

In children with CP and mild ID, it was found that the level I GMFCS-E&R accomplishes tasks within the TGMD-2 by achieving the statistically highest average score, followed by level II, and the lowest results are achieved by the level III GMFCS-E&R. Also, it was concluded that children with CP and mild ID at each level of GMFCS-E&R achieve higher standardized score at the assessment of locomotor skills, than at the assessment of object control skills.

In children with CP and moderate ID, different results were obtained. Statistical analysis indicated that children at level I of this group accomplished tasks within TGMD-2 achieving the highest average score that statistically differs from other two groups. Although, there were detected differences in achievement on TGMD-2 tasks between level II and level III children of this group, they were not statistically significant. It was concluded that the

children at level II and level III of this group achieved statistically better results by solving locomotor skills tasks than the object control tasks. Children at level I group are solving the tasks of locomotor skills and object control with the same quality.

The results of this study indicate a better quality of locomotor skills than the object control skills in children with CP and associated ID. Also, the better the quality of the locomotor skills, the better is the quality of the object control. Gross motor skills are developed in the pre-school period and are often learned through motor imitation.<sup>[29]</sup> Locomotor skills are more automated and less dependent on cognitive functioning, while performing object control skills requires more involvement of cognitive processes.<sup>[30]</sup> Considering the specificity of the study sample, we can say that our results in this segment are expected.

It was concluded that the severity of ID affects the quality of gross motor skills. Children with CP and moderate ID had statistically poorer quality of locomotor skills and object control compared to children with CP and mild ID. These results are in line with the results of previous authors who found that the severity of ID is crucial for the quality of motor behavior in children with reduced cognitive functioning.<sup>[5,12,31,32]</sup>

The subjects of this sample showed difficulties when performing purposeful actions composed of sequences of individual movements. This indicates an unfinished dynamic cooperation of cognitive systems that include task understanding, object knowledge, and spatial orientation. The basis for such findings can be found in the problems of conceptualization and mental rotation that are known in the literature.<sup>[28]</sup> A problem of cognitive nature has been recorded in tasks that require rapid alteration of motor activity in accordance with verbal orders, which is also in line with literature claims.<sup>[33]</sup>

The structure of motor behavior of subjects with CP and associated ID during this study was characterized by frequent incorrect motions, movement omissions, and movement

errors. The examiners registered exclusion of some sequences within tasks, prolonged time in performing them or the unnecessary repetition of motor sequences. Some of these specificities have been registered in previous studies.<sup>[34]</sup>

Our findings could be incorporated into an individual developmental rehabilitation plan and could be an important guideline in the development of gross motor potential of children with CP and associated ID by applying proper rehabilitation program.

This paper has several limitations. The inclusive study criterion included children with CP I, II and III levels of GMFCS-E&R, so, children with the ability to walk with or without aids. This was important in the assessment of locomotor skills. Nevertheless, object control skills should be evaluated for children who can participate in the assessment while sitting in a wheelchair. Furthermore, the sample size is small. However, the exclusive criteria implied absence of epilepsy, sensory disturbances and other medical conditions, which are frequent companion of CP. We included the required number of participants to obtain statistical power sufficient to detect a certain effect size, because new respondents were not available. Since this paper included only children with spastic type CP, as they are the most numerous within the ID<sup>[4]</sup>, future studies should examine the specifics of gross motor skills in other types of CP with associated ID and provide guidelines for creating an individual developmental rehabilitation plan.

In conclusion, the results of this study show significant interconnection of gross motor functions quality (locomotor skills and object control skills) and intellectual capacity in preschool children with CP. If the quality of motor functions is severely impaired, children with CP will have more difficulties in learning processes that are conditioned by intellectual capacity. Frequent training of gross motor function will allow better intellectual outcome for these children, so it is necessary to subject these abilities together to the rehabilitation process. We believe that the topic of this study, of which there is little research data, will help

in the detailed creation of an individual developmental rehabilitation plan for children with CP and associated ID.

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### **Declaration of conflicting interests**

The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

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Table 1. Demographic and clinical characteristics of the respondents

Characteristics	n	%	Mean $\pm$ SD
Age			5.74 $\pm$ 0.82
Sex			
Male	30	55.6	
Female	24	44.4	
CP type			
Spastic diplegia	35	64.81	
Spastic hemiplegia	19	35.19	
Body Mass Index (kg/m <sup>2</sup> )			16.7 $\pm$ 1.2
ID category			
Mild	28	51.9	
Moderate	26	48.1	
GMFCS-E&R			
I	14	25.93	
II	18	33.33	
III	22	40.74	

Legend: Values are mean  $\pm$  standard deviation (SD) or frequency and percentage. CP: cerebral palsy. ID: intellectual disability. GMFCS-E & R: Gross Motor Function Classification System-Expanded and Revised.

Table 2. Distribution of GMFCS-E&amp;R and ID category

ID category	GMFCS-E&R levels		
	I	II	III
Mild	9 (16.7)	10 (18.5)	9 (16.7)
Moderate	5 (9.3)	8 (14.8)	13 (24.0)

Legend: Values are n (%)

Table 3. Descriptive values of TGMD-2 for children with CP and mild ID (Mean  $\pm$  SD)

	GMFCS-E&R levels		
	I	II	III
Locomotor Skills			
Run	5.06 $\pm$ 1.72	4.22 $\pm$ 1.13	2.12 $\pm$ 0.78
Gallop	4.20 $\pm$ 2.49	3.00 $\pm$ 1.18	0.65 $\pm$ 0.39
Jump	4.73 $\pm$ 2.17	4.01 $\pm$ 2.72	1.12 $\pm$ 0.45
Horizontal jump	4.36 $\pm$ 2.14	3.06 $\pm$ 1.69	1.56 $\pm$ 1.01
Leap	2.70 $\pm$ 1.26	1.97 $\pm$ 1.03	0.70 $\pm$ 0.39
Slide	5.66 $\pm$ 2.07	4.23 $\pm$ 2.18	3.18 $\pm$ 1.22
Total subtest score	26.30 $\pm$ 9.65**	20.43 $\pm$ 7.18**	9.92 $\pm$ 4.08**
Standardized score	9.06 $\pm$ 2.74**	7.28 $\pm$ 2.25*	5.36 $\pm$ 2.43*
Object Control			
Striking a stationary ball	2.26 $\pm$ 1.05	1.66 $\pm$ 1.04	0.91 $\pm$ 0.62
Stationary dribble	4.40 $\pm$ 2.17	2.88 $\pm$ 1.22	1.18 $\pm$ 0.53
Catch	4.50 $\pm$ 1.59	2.95 $\pm$ 1.78	1.14 $\pm$ 0.45
Kick	5.96 $\pm$ 1.42	4.17 $\pm$ 1.33	2.22 $\pm$ 0.27
Overhand throw	1.80 $\pm$ 1.88	0.97 $\pm$ 0.56	0.53 $\pm$ 0.32
Underhand roll	3.63 $\pm$ 2.44	2.15 $\pm$ 0.72	1.21 $\pm$ 1.07
Total subtest score	22.90 $\pm$ 8.87**	15.18 $\pm$ 5.56**	7.23 $\pm$ 3.13**
Standardized score	8.56 $\pm$ 2.64**	5.98 $\pm$ 2.13*	4.17 $\pm$ 2.48*
Total score	8.81 $\pm$ 2.69	6.63 $\pm$ 2.19	4.77 $\pm$ 2.46

Legend: \*  $p < 0.05$ ; \*\*  $p = 0.001$

Table 4. Descriptive values of TGMD-2 for children with CP and moderate ID (Mean  $\pm$  SD)

	GMFCS-E & R levels		
	I	II	III
<b>Locomotor Skills</b>			
Run	0.93 $\pm$ 0.75	0.33 $\pm$ 0.26	0.22 $\pm$ 0.17
Gallop	0.80 $\pm$ 0.34	0.20 $\pm$ 0.18	0.00 $\pm$ 0.00
Jump	0.26 $\pm$ 0.19	0.06 $\pm$ 0.08	0.00 $\pm$ 0.00
Horizontal jump	1.20 $\pm$ 0.87	0.79 $\pm$ 0.44	0.54 $\pm$ 0.16
Leap	0.13 $\pm$ 0.15	0.06 $\pm$ 0.11	0.08 $\pm$ 0.03
Slide	1.20 $\pm$ 0.91	1.01 $\pm$ 0.72	0.99 $\pm$ 0.78
Total subtest score	4.40 $\pm$ 3.74**	2.85 $\pm$ 2.14	2.37 $\pm$ 1.74
Standardized score	2.73 $\pm$ 2.40	2.27 $\pm$ 1.56*	1.97 $\pm$ 1.45*
<b>Object Control</b>			
Striking a stationary ball	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00
Stationary dribble	0.13 $\pm$ 0.21	0.05 $\pm$ 0.12	0.00 $\pm$ 0.00
Catch	0.93 $\pm$ 0.62	0.43 $\pm$ 0.09	0.22 $\pm$ 0.08
Kick	1.53 $\pm$ 1.13	0.62 $\pm$ 0.07	0.54 $\pm$ 0.10
Overhand throw	0.20 $\pm$ 0.41	0.09 $\pm$ 0.02	0.07 $\pm$ 0.02
Underhand roll	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00
Total subtest score	2.40 $\pm$ 2.18**	1.29 $\pm$ 0.88	1.03 $\pm$ 0.28
Standardized score	2.33 $\pm$ 0.89	1.26 $\pm$ 0.44*	1.01 $\pm$ 0.25*
Total score	2.53 $\pm$ 1.65	1.77 $\pm$ 1.15	1.49 $\pm$ 0.85

Legend: \*  $p < 0.05$ ; \*\*  $p = 0.001$

Table 5. Intercorrelation matrix for TGMD-2 subtests

	1	2	3	4	5	6	7	8	9	10	11
<b>Locomotor Skills</b>											
1. Run											
2. Gallop	0.42**										
3. Jump	0.45**	0.51**									
4. Horizontal jump	0.50**	0.46**	0.35**								
5. Leap	0.47**	0.52**	0.69**	0.42**							
6. Slide	0.30*	0.31*	0.29*	0.33**	0.39**						
<b>Object Control</b>											
7. Striking a stationary ball	0.23*	0.34**	0.37**	0.45**	0.42**	0.62**					
8. Stationary dribble	0.38**	0.29*	0.44**	0.61**	0.53**	0.66**	0.58**				
9. Catch	0.36**	0.55**	0.67**	0.70**	0.72**	0.20*	0.59**	0.65**			
10. Kick	0.30*	0.72**	0.47**	0.61**	0.75**	0.32*	0.69**	0.30*	0.48**		
11. Overhand throw	0.31*	0.29*	0.37**	0.33**	0.56**	0.34**	0.68**	0.70**	0.78**	0.39**	
12. Underhand roll	0.39**	0.44**	0.56**	0.36**	0.43**	0.53**	0.76**	0.81**	0.85**	0.88**	0.47**

Legend: \*  $p < 0.05$ ; \*\*  $p < 0.01$

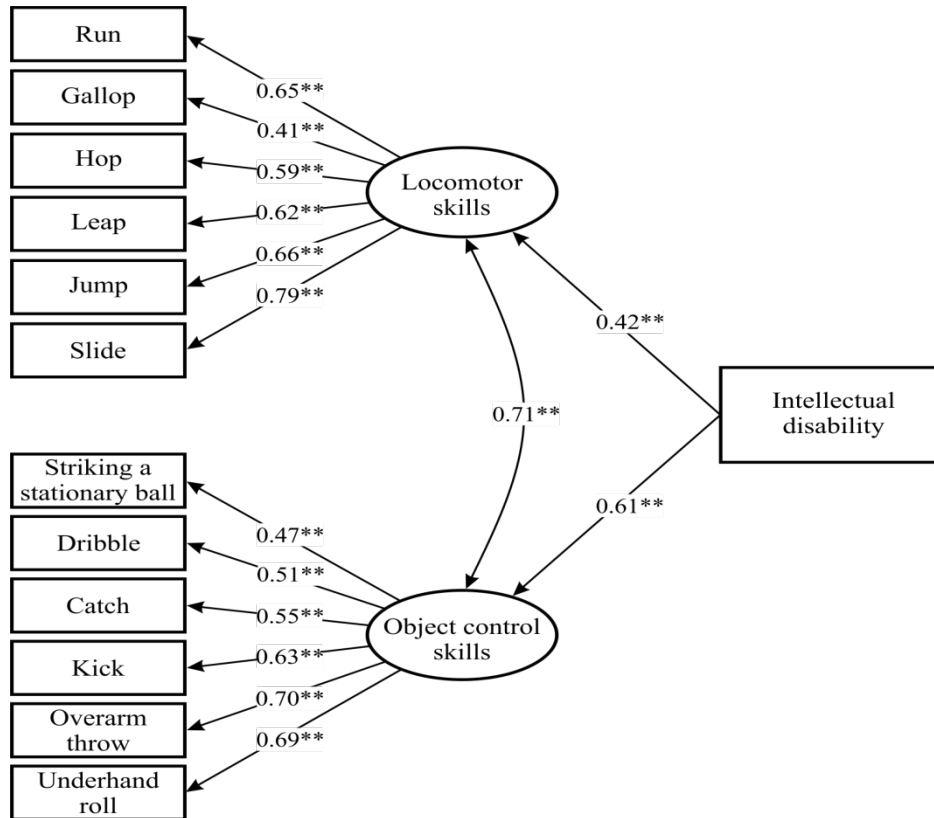


Figure 1. Confirmatory factor analysis of TGMD-2 with covariance ID - layout of the final structural model; \*\*  $p < 0.01$