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RELIABILITY AND VALIDITY OF TGMD-2 IN SERBIA FOR CHILDREN AGED 7–8

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ABSTRACT

The Test of Gross Motor Development (TGMD-2) was developed to assess the motor development of children aged 3–10 focusing on motor skills. The TGMD-2 is widely used in research and clinical settings. The aim of the study was to investigate the content, criteria, and construct validity and reliability of the TGMD-2 for children aged 7–8 in Serbia.

The study involved 214 children (47.19% girls) from the northern part of Serbia. The two-factor model was confirmed by factor analysis. Internal consistency reliability was high: for locomotor score (.76), object control score (.77) and total composite score (.81). The test-retest reliability ranged from .31–.79, and it was significant ($r = .55$; $p \leq .00$). This study highlighted that TGMD-2 can be used with confidence to assess motor skills of children in Serbia aged 7–8.

***Key* words**

children, motor skills, Test of Gross Motor Development-2, factor analysis.

Introduction

For the optimal cognitive development of children, it is necessary for them to discover their surroundings using motor skills (movement). In early childhood, children "spend" a lot of time finding out about their environment, they do it through motor activities: crawling, walking, jumping and running (Goodway, Ozmun, Gallahue, 2019).

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Motor skills include locomotor skills, where the human body is moved from one point to another point (e.g., jumping over a bar), and manipulative skills that involve object control (e.g., passing, catching, throwing, kicking a ball). During these activities, the children learn how to coordinate and control their own body, using feedback from the environment (Starc, Čudina-Obradović, Pleša, Profaca, Letica, 2004). The acquisition of locomotor and control skills occurs in the phase of fundamental movements, which, according to Gallahue & Ozmun (1998), consists of three stages.

In the initial stage (ages 2–3), children make their first visible (observable) and purposeful attempts during the performance of the task. This stage is characterized by relatively coarse, uncoordinated movements. Children may have successful attempts at throwing, catching, kicking, or jumping, but major components of a mature movement pattern are still missing, with their movements either greatly exaggerated or inhibited. Rhythmic execution of movements is also missing.

The elementary stage (ages 3–5) of motor development seems to depend primarily on maturation. In this transitional period between the initial and mature stages, the children's coordination and rhythmic performance improve and they gain greater control over their movements. However, the movements at this stage still seem slightly clumsy and not sufficiently fluid.

The mature stage (ages 6–7) is characterized by efficient, coordinated and controlled mechanical movements. Children have the developmental potential to reach the mature stage for most fundamental movements at ages 6–7. Only the manipulative skills that require tracking and grasping moving objects develop somewhat later due to the complex visual-motor requirements of these tasks. However, children often reach this stage at different paces. In some children, it is delayed (slowed down), or they fail to reach this stage in certain skills. There are also more advanced children who arrive at this level much faster. If there is a deficit in motor skills that is not corrected in time, it may pose problems throughout the child's life. Moreover, from a psychological aspect, the child will have a problem with self-image (self-confidence) and motivation.

Mature fundamental movement skills form the basis of all sports skills and must therefore be acquired. Should this fail to happen, a closed circle of frustration and failure is triggered: insufficiently developed fundamental motor skills will prevent children from engaging in more complex motor activities (sports, recreation), leaving them barred from participating in exercise, with their lag increasing.

Before starting school, children should be able to walk neatly, run correctly, throw and catch the ball skillfully, hit the target. They deftly and courageously climb high ladders, leap over obstacles, jump high, far and deep, walk on devices at a height of up to 1m. During this period, they learn to swim, skate, ski, roller skate,

ride a bicycle without auxiliary wheels, and play football, among others (Gallahue & Ozmun, 1998).

Fundamental motor skills are divided into three basic categories (Sanders, 1992):

- locomotor skills – walking, running, jumping, hopping,
- non-control skills – turning, leaping, sliding,
- control skills (object control) – kicking, throwing, catching, hitting, dri-bbling, pushing, pulling.

During preschool and younger school age, motor skills develop the most (Clark, 1994; Gallahue & Ozmun, 1998; Payne & Isaacs, 1999). Mastery of these skills plays a key role in the subsequent acquisition of more complex motor skills required for sports and play (Burton & Miller, 1998).

The development of motor skills in certain time periods or maturation depends on many factors (Medved et al., 1987), such as: physical growth and deve-lopment, environmental influence, socioeconomic status and physical activity, and hereditary traits (Gallahue & Ozmun, 1998; Jürimäe & Jürimäe, 2000).

Enabling children to be physically active is of crucial importance, as all phases of motor development – regardless of the level of activity – require numerous repetitions of movement, and a quality physical education program should be based on an understanding of developmental stages and growth patterns in order to support the development of motor skills (Clark, 2005).

The advantage of this research lies in the fact that the reliability and validity of the TGMD-2 were examined for the first time in Serbia among children aged 7 to 8 years.

In addition, the research was conducted in a school setting, under natural conditions for the children, which increases the ecological validity of the findings. A limitation of the study is the geographical restriction of the sample, as the participants were students from the Subotica municipality.

This may affect the external validity of the findings and limits the possibility of generalizing the results to the entire population of children in Serbia, particularly in rural areas and culturally and ethnically diverse environments.

Despite this limitation, the research fulfills its primary goal, assessing the content, criterion, and construct validity and reliability of the TGMD-2 among children in Serbia aged 7 to 8 years and provides a foundation for future studies and the application of the instrument in broader samples and different contexts.

Methods

Sample. The choice of the sample of respondents was, first of all, conditioned by the organizational and material possibilities for carrying out the measurements. In these types of studies it is important to ensure the presence of teams of qualified and trained measurers, as well as equipped halls for physical education, with prescribed dimensions (at least the dimensions of a basketball court), where measurements can be performed under standardized conditions. The selection of elementary schools in Subotica was random, all meeting the condition of having a hall of optimal dimensions.

The sample of respondents was represented by second-grade students, aged 7 to 8 years (SD ± .29) of randomly selected elementary schools from the municipality of Subotica, accompanied by their parents. Using the G*Power software (Faul, Erdfelder, Lang, Buchner 2007), the required sample size of students (or parents) was calculated. A critical value of the F test of 2.05 and a target effect level of .35 were determined using an alpha level of $p \leq .05$ and a sensitivity of the test of .95; 214 students (101 girls) were measured. The average age of the examined students was 7.71 ± .29 years. School principals, parents, teachers and students were all informed about the aim and content of the research and their written consent was obtained in advance.

All students included in the research regularly attended physical education classes three times a week, held by female teachers in their classes, according to the prescribed physical education curriculum for the second grade of elementary school. All examined students were healthy at the time of measurement, without physical defects or developmental disabilities.

Instruments. The Test of Gross Motor Development-2 (TGMD-2) was used to assess the development of fundamental motor skills. TGMD-2 is a tool for assessing the development of motor skills based on observational techniques. It is designed to assess the development of gross motor skills in children aged 3–10. The test was originally validated in 2000 (Ulrich, 2000). Norms were developed based on data obtained from a sample of 1208 children aged 3–10, from 10 different states in the USA. The test assesses 12 gross motor skills divided into two categories (subscales): locomotor skills and object control skills.

Gross motor skills engage large muscle groups that enable the most important movements such as walking, running, jumping, maintaining balance, throwing, etc. These skills depend on muscle tone and strength, and children with better developed gross motor skills engage in physical activity more easily than children with less developed skills. Locomotor skills are skills that require fluid body movements as the child moves in space. Object control skills require effective throwing, hitting, and catching movements (Ulrich, 2000).

For each skill, certain criteria are observed, for each fulfilled criterion the examinee receives 1 point, and if the criterion is not met, the examinee receives 0 points. The examinee must perform each skill twice. Testing can usually be done in 10–20 minutes per subject. The sum of all criteria from each subscale constitutes the raw score for the given subscale (0–48 points). TGMD-2 consists of two subscales (Locomotor skills, Object control). Adding the raw scores from the two subscales results in a total raw score (0–96 points).

This score is the most useful value obtained from the TGMD-2, as it reflects the underlying constructs embedded in the test and is highly reliable. The TGMD-2 is recognized as a valuable instrument in the identification of delays in motor development (Netelenbos, 2005) and has also been used to test children with sensory limitations and those with cognitive problems. The TGMD-2 provides a valid assessment of a child's current development of fundamental motor skills. Raw grades can be converted to percentile ranks and standard grades and compared to peers' ranks.

The most reliable score of the TGMD-2 is the Coefficient of Motor Development, which consists of the scores of two subscales. After converting the raw scores into standard scores (Table B.1, B.2, B.3, pp. 53–56), the standard scores were converted into motor development coefficients using the corresponding table (Table C.1) found in the manual for TGMD-2 (Ulrich, 2000: 58). High values of the coefficients indicate well-developed locomotor skills and object control skills. Such children will be described as skillful, well-coordinated, with smooth movements, with good visual-motor integration, while low coefficients are achieved by children who have weak locomotor skills and object control skills.

Test of gross motor development-2 (Ulrich, 2000) consists of two subscales:

(A) The first subscale serves to assess locomotor skills:

1. Run (1 point),
2. Gallop (1 point),
3. Hop (1 point),
4. Leap (1 point),
5. Horizontal jump (1 point),
6. Slide (1 point);

(B) The second subscale serves to assess object control (ball):

7. Striking a stationary ball (1 point),
8. Stationary dribble (1 point),
9. Catch (1 point),
10. Kick (1 point),

11. Overhand throw (1 point),

12. Underhand roll (1 point).

The standardized procedure continued with administering the TMGD-2 for research purposes, including the following elements:

(1) Before the study participants were allowed to perform the task, they were shown an accurate demonstration of the skill and given an explanation of what they were to do;

(2) Before the testing (evaluation), the participants tried to perform the task once, to make sure that they properly understood what they had to do;

(3) When it seemed that the participant failed to completely grasp the task, the specific skill was demonstrated again;

(4) The participants performed each task (skill) twice and each attempt was evaluated according to all criteria and logged;

(5) During the testing, the participants did not receive feedback regarding the accuracy of the task performed (e.g., "That was good");

(6) First, the dominant hand and foot was determined for each participant by the prompts “Give me five!” and “Kick the ball over!”;

(7) Locomotor skills were tested before object control skills.

Results

Metric characteristics of TGMD-2. Given that it is a measuring instrument used for the first time in this environment, it was necessary to determine its metric characteristics, such as validity, reliability and objectivity. In previous studies the metric properties of the TGMD-2 were tested in a sample of children in the USA (Ulrich, 2000), Brazil (Valentini, 2012), South Korea (Chung-Il, Dong-Wook, Il-Hyeok, 2014), and Iran (Farrokhi, Zareh Zadeh, Karimi Alver, Kazemnajed, Ilbeigi, 2014). The validity of the TGMD-2 was examined by promax factor analysis, which obtained the main components of motor skills (Table 1).

Table 1. Two-factor model of TGMD-2

	Locomotor skills	Object control
Run	.33	-.12
Gallop	.54	-.18
Hop	.49	.22
Leap	.34	.29
Horizontal jump	.53	-.27

	Locomotor skills	Object control
Slide	.37	.16
Striking a stationary ball	-.07	.31
Stationary dribble	-.06	.75
Catch	.28	.49
Kick	-.24	.58
Overhand throw	-.05	.49
Underhand roll	.03	.36
% variance	16.51	10.96

The isolated significant principal components were rotated using the promax method and on the basis of the assembly and structure matrix and intercorrelations, two factors were named in motor skills. The first factor, Locomotor Skills, accounted for 16.51% of the shared variability, the second factor, Object Control, accounted for 10.96% of the shared variability. The correlation between those two factors was r = .22. The theoretical assumption about the relative independence of these factors was confirmed, because the obtained components were not mutually dependent.

Based on the data shown in Tables 1 and 2, it can be stated that the two-component model of validity according to Ulrich (Ulrich, 2000) was confirmed by Valentini (2012) and in the current sample.

Table 2. Validity of the TGMD-2 in previous studies

Variables	Ulrich, 2000		Valentini, 2012	
	Locomotor skills	Object control	Locomotor skills	Object control
Run	.52	-	.46	-
Gallop	.66	-	.71	-
Hop	.70	-	.66	-
Leap	.49	-	.53	-
Horizontal jump	.59	-	.53	-
Slide	.69	-	.55	-
Striking a stationary ball	-	.75	-	.69
Stationary dribble	-	.61	-	.56
Catch	-	.57	-	.59
Kick	-	.65	-	.75
Overhand throw	-	.75	-	.69
Underhand roll	-	.67	-	.45

Scale reliability (internal consistency) was tested using Cronbach's alpha coefficients. The reliability analysis of the TGMD-2 is presented in Table 3.

Table 3. Reliability of the Test of Gross Motor Development-2 (TGMD-2)

Variables	*N*	*α*
LOCOMOTOR SKILLS	6	**.76**
1. Run	8	.66
2. Gallop	8	.52
3. Hop	10	.65
4. Leap	6	.77
5. Horizontal jump	8	.75
6. Slide	8	.85
OBJECT CONTROL	6	**.77**
1. Striking a stationary ball	10	.48
2. Stationary dribble	8	.79
3. Catch	6	.52
4. Kick	8	.69
5. Overhand throw	8	.44
6. Underhand roll	8	.58
Motor development coefficient	2	**.81**

N – items number; α – Cronbach's reliability coefficient

Cronbach's alpha coefficients for the locomotor skills and object control subscales reached an acceptable value (.76 and .77), i.e., they were at the high reliability limit. The value of the alpha coefficient for the entire scale (Coefficient of motor development) was .81, indicating that the reliability was high (Armitage & Theodore, 1998; Burton & Miller, 1998).

To check the reliability of the TGMD-2, a test-retest procedure was used on a smaller sample (18.22%), i.e., the test was repeated ten days apart. Significant medium-high correlations were obtained between the two measurements in the raw data of the TGMD-2 ($r = .55$; $p \leq .00$) as well as in all individual items ($r = .31–.79$).

Discussion

The aim of this study was to evaluate the content, criterion, and construct validity, as well as the reliability of the Test of Gross Motor Development-2 (TGMD-2) among children in Serbia aged 7 to 8 years. Considering the importance of gross motor skill development during this sensitive developmental period, the study sought to determine whether the instrument could be applied reliably and validly within the Serbian context.

According to Nićin (2000), motor skills are learned, acquired movements, but also movements that are recorded by the genetic code in the central nervous system

(CNS), such as natural forms of movement (walking, running, jumping, throwing, etc.). The process of acquiring motor skills is related to the learning process, which is closely connected to the information received through receptors (inter-, exter-, body- and proprioreceptors).

Part of the information is recorded in genes and in DNA as a genetic code, and much of human functioning depends on them. Motor skill development is defined as the change in motor skill behavior over time and the processes that underlie these changes (Abernethy, Kippers, Mackinnon, Neal, Hanrahan, 1997). With physical development and motor experience, changes can be influenced, that is, correct motor movements can be adopted (Ulrich & Ulrich, 1993).

The measuring instrument Test of Gross Motor Development-2 (TGMD-2) was used for the first time in Serbia and its metric characteristics were determined. The test can be applied to children aged 7–8. It can serve the purpose of identifying individuals who lag behind in motor development compared to their peers, but also those who are significantly ahead of their peers, making it possible to devise programs for their optimal development accordingly.

The level of motor development of children from Subotica, assessed on the basis of raw scores on the Locomotor Skills and Object Control subscales, is lower than that of children from the USA (Ulrich, 2000), but higher than that of children from the Czech Republic (Cepicka, 2010), Brazil (Valentini, 2012), and Iran (Farrokhi et al., 2014).

These findings are consistent with previous international studies, which have emphasized the influence of sociocultural, environmental, and infrastructural factors on the acquisition of fundamental motor skills (Clark, 1994; Gallahue & Ozmun, 1998). The results confirm that even within the same age groups, substantial differences in motor proficiency can be observed between countries, likely due to differences in physical activity habits, educational systems, and opportunities for motor learning.

Previous research (Farrokhi et al., 2014; Kim, Kim, Valentini, Clark, 2014) revealed that these differences occur because the TGMD-2 consists of such tests that assess skills not traditionally practiced in certain regions, such as striking a stationary ball. This factor partly explains the lower results achieved by children from Subotica compared to their peers in the USA (Ulrich, 2000). Valentini (2012) similarly reported lower performance in Brazilian children on tasks uncommon within their regular physical activity routines, highlighting the importance of contextualizing test outcomes based on culturally specific motor experiences.

Additionally, this research confirms that the TGMD-2 is a reliable and valid tool for assessing fundamental motor skills within this specific cultural and environmental context. Its application in schools and clinical practice can support the early detection of motor delays, enabling timely intervention and the implementation of structured, individualized physical education programs. As Gallahue &

Ozmun (1998) pointed out, early identification and intervention are critical, as the fundamental movement phase represents a sensitive period for motor skill acquisition, directly influencing later participation in sports and physical activities.

Furthermore, the findings of this study provide a valuable foundation for future research aimed at longitudinal monitoring of motor skills in children, as well as cross-cultural comparisons in motor development. Expanding the use of TGMD-2 across different regions of Serbia may contribute to the establishment of national norms, which would be valuable for both educational and healthcare systems. By identifying regional differences and specific developmental trends, practitioners and policymakers can better address the needs of children and improve the overall quality of physical education and motor skill interventions in early childhood.

Moreover, the practical application of TGMD-2 could play a significant role in developing preventive strategies. As Clark (1994) and Gallahue & Ozmun (1998) emphasized, motor skill development during early childhood is influenced by numerous factors, including physical growth, environmental conditions, and socio-economic status.

Regular and systematic assessment using reliable instruments like the TGMD-2 allows for the timely identification of developmental delays, contributing to the creation of appropriate support programs that encourage physical literacy and lifelong engagement in physical activities.

Finally, this study's outcomes also confirm Ulrich's (2000) assertion that TGMD-2 is a valuable diagnostic tool adaptable to different populations, offering both a screening and evaluative function. Its continued application in diverse contexts, as demonstrated by Valentini (2012) in Brazil, Farrokhi et al. (2014) in Iran, and Kim et al. (2014) in South Korea, further validates its global relevance. The successful validation of the TGMD-2 in Serbia opens new possibilities for research focused on different age groups, children with developmental challenges, and regional comparisons, thereby enriching the knowledge base necessary for advancing physical education and health promotion policies.

Conclusion

The assessment and evaluation of children's motor skill levels are essential for the early identification of deviations in motor development. The TGMD-2 enables the detection of children who are either lagging behind or more advanced compared to their peers, which provides a basis for designing targeted physical and motor development programs. TGMD-2 is a reliable and valid measurement instrument for assessing the motor skills of children aged 7 to 8 years in Serbia.

Based on the results, the motor development level of children from Subotica differs from that of children in other countries, which may be due to cultural and sports-related differences.

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