

Research article

## POLYGON – A new fundamental movement skills test for 8 year old children: construction and validation

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### Abstract

Inadequately adopted fundamental movement skills (FMS) in early childhood may have a negative impact on the motor performance in later life (Gallahue and Ozmun, 2005). The need for an efficient FMS testing in Physical Education was recognized. The aim of this paper was to construct and validate a new FMS test for 8 year old children. Ninety-five 8 year old children were used for the testing. A total of 24 new FMS tasks were constructed and only the best representatives of movement areas entered into the final test product – FMS-POLYGON. The ICC showed high values for all 24 tasks (0.83-0.97) and the factorial analysis revealed the best representatives of each movement area that entered the FMS-POLYGON: *tossing and catching the volleyball against a wall, running across obstacles, carrying the medicine balls, and straight running*. The ICC for the FMS-POLYGON showed a very high result (0.98) and, therefore, confirmed the test's intra-rater reliability. Concurrent validity was tested with the use of the "Test of Gross Motor Development" (TGMD-2). Correlation analysis between the newly constructed FMS-POLYGON and the TGMD-2 revealed the coefficient of -0.82 which indicates a high correlation. In conclusion, the new test for FMS assessment proved to be a reliable and valid instrument for 8 year old children. Application of this test in schools is justified and could play an important factor in physical education and sport practice.

**Key words:** TGMD, reliability, validity, movement skills, norm-referenced.

### Introduction

Fundamental movement skills (FMS) can be defined as basic motor activities that underlie all complex specific activities like sport-specialized skills (Wickstrom, 1983). Some authors relate to them as locomotor and object control skills performed in an upright position that are used worldwide regardless of the culture (Burton and Miller, 1998). Most scientists emphasize FMS as inevitable factors in human development during ontogenesis. FMS allow children to move through space (Zittel, 1994) and provide knowledge of reaction to different stimuli (Krebs, 2000). Skills that are inadequately adopted in early childhood may have a negative impact on the motor performance in later life (Gallahue and Ozmun, 2005). In fact, mastering these skills is a prerequisite to the successful introduction of specific sport activities (Burton and Miller, 1998; Gallahue and Ozmun, 2005; Jurimae and Jurimae, 2000; Karabourniotis et al., 2002; Okely and Booth, 2004) with practice being crucial to their development (Gallahue and Ozmun, 2005). Those children that do not overcome the basic patterns of these skills will not

be able to successfully and effectively participate in sport related activities during their lifetime (Gallahue and Donnelly, 2003; Payne and Isaacs, 2007).

Two assessment approaches of FMS can be distinguished. The norm-referenced approach measures the product or outcome of the performance, while the criterion-referenced approach focuses on the form or technique of the movement, in other words, how the skill is performed. However, there are pros and cons for each method of assessment. Tests with the norm-referenced approach, like the "Bruininks-Oseretsky Test of Motor Proficiency" (Bruininks and Bruininks, 2005), can be done faster than criterion-referenced tests and are capable of testing more participants in less time, but those tests do not provide direct information about the proficiency of the performance. Tests that include the criterion-referenced approach, like the "Test of Gross Motor Development" (Ulrich, 2000), can be used to inform the teacher or coach which specific components of a skill an individual needs to practice. The disadvantages of criterion-referenced assessment include the difficulty of comparing results that have been gathered by different assessors and, also, the considerable amount of time needed for assessing a large number of participants. According to Davis (1984) this type of assessment procedures are not commonly used due to lack of training, lack of standardization and lack of data to guide teachers in how to interpret student performances in tests.

According to the studied literature, various authors and various cultures include different classification of the FMS: locomotor and object control skills (Burton and Miller, 1998); locomotor, object control and stability skills (Gallahue and Donnelly, 2003); space covering, surmounting obstacles, resistance overcoming and object control skills (Mrakovic et al., 1993). Burton and Miller (1998) state that locomotor skills include walking, running, jumping, sliding, hopping and leaping while the object control skills include throwing, catching, striking, bouncing, kicking, pulling and pushing. One of the widely used tests for FMS assessment – the "Test of Gross Motor Development" (TGMD-2) (Ulrich, 2000) is based upon the mentioned classification and is a criterion-referenced test. The second classification by Gallahue and Donnelly (2003) records FMS nearly the same as the earlier mentioned authors with the addition of skipping, galloping, climbing and leaping in the locomotor area and trapping, volleying, ball rolling and punting in the object control area. They also include bending, stretching, twisting, turning, swinging, inverted supports, body rolling, landing/stopping, dodging and balancing in the stability area.

The “Bruininks-Oseretsky Test of Motor Proficiency, Second Edition” (BOT-2) (Bruininks and Bruininks, 2005) and the “Peabody Developmental Motor Scales, Second Edition” (PDMS-2) (Folio and Fewell, 2000) include this classification with BOT-2 being a norm-referenced and PDMS-2 a criterion-referenced test. The classification of the FMS by Mrakovic et al. (1993) includes all kinds of different activities depending on the movement area and utility. The importance of this classification has been recognized with the Croatian Physical Education Curriculum being based on it. Classification itself, not being so much different from the TGMD-2 where tasks can also be divided in more than two categories, has a perennial use in the educational system. The need for a quick and effective FMS testing in Physical Education exists since no attempts have been made to construct a norm-referenced test on the base of the previously mentioned classification to this date. Also, the need for a norm-referenced assessment tool can be identified since evaluation of skill mastery through criterion-referenced tests requires more precise evaluation which assumes a certain amount of time that PE teachers rarely have. Since significant relationship between the two assessment approaches has already been confirmed by previous investigations (McIntyre, 2000; Robertson and Konczak, 2001; Miller, 2002) it can scientifically be justified to construct a norm-referenced test which can be easily administered for PE purposes.

Therefore, the main aim of this study was to construct and validate a new fundamental movement skills assessment tool for 8 year old children according to the Mrakovic et al. (1993) movement skills classification. For that purpose we: (1) estimated the intra-rater reliability of the 24 newly constructed FMS tasks; (2) determined the four tasks that best represent the specific movement skills area; (3) estimated the intra-rater reliability of the newly constructed FMS polygon; (4) estimated the concurrent validity of the newly constructed FMS polygon by investigating a correlation with a validated FMS test. It was hypothesized that the newly constructed FMS polygon will make valid measurement compared to the TGMD-2.

## Methods

### Subjects

Ninety-five children (48 boys and 47 girls) aged 8 years old ( $8.1 \pm 0.3$ ) attending elementary schools in Split, Croatia participated in the investigation. Boys averaged  $1.34 \pm 0.06$  m in height and  $30.3 \pm 5.91$  kg in weight and with a BMI of  $16.8 \pm 2.31$  which is consistent with the previous research (Bonaccorsi et al, 2009). Girls averaged  $1.34 \pm 0.05$  m in height and  $30.3 \pm 5.69$  kg in weight and with a BMI of  $16.7 \pm 2.46$ . Other authors also gained similar results (Miletic et al., 2004). All of them were chosen randomly from a population of 300 children from three schools. They all gave verbal assent and their parents gave written informed consent. From a total of 95 children, 21% were involved in activities that are characterized by manipulation of objects (soccer); 40% attended activities in which moving and controlling the body in space is the main objective (dance, gymnastics, swim-

ming, ballet); 19% participate in combat sports which are comprised of resistance overcoming (karate, taekwondo, judo); and 20% did not participate in any organized activities. The Ethical Committee of the *Faculty of Kinesiology – University of Split* verified that this investigation complied with all ethical standards for scientific investigations involving human participants.

### Study design

The research was organized in several phases: the first phase included the construction of the 24 tasks for fundamental movement skills assessment. Tasks were chosen according to their use in the PE program. For that purpose a pilot testing was conducted among 10 children aged 8 years to verify the practical realization of the tasks, correct any possible shortcomings and, most important, make sure all the tasks were equally timed. After those corrections and verifications ninety-five pupils were tested for 24 new fundamental movement skills tasks. Every task was repeated three times to assess reliability.

After selecting a battery of four tasks that best represent a certain movement skills area, the investigation entered into the second phase by constructing the new fundamental movement skills assessment tool – polygon (FMS-POLYGON). A definition of polygon connotes a successive execution of a certain number of tasks in a shortest time possible. A pilot testing was conducted among 20 children aged 8 years to assure the practical realization of the test and correct any possible limitations. After that, a representative sample of ninety-five pupils was tested for a new FMS-POLYGON. Every participant saw the demonstration of the FMS-POLYGON and then repeated it four times (with first time being the practice one, with no time recording) to assess the intra-rater reliability of the test.

The third phase of the investigation included an assessment of the fundamental movement skills by a validated test – TGMD-2. As recommended (Ulrich, 2000) all participants were videotaped and their level of FMS assessed by a single examiner.

### Measurements

*The set of newly constructed fundamental movement skills tasks:* According to Mrakovic et al. (1993) all fundamental movement skills or so-called natural forms of movement can be divided according to their utility into the following groups: space covering skills, surmounting obstacles skills, resistance overcoming skills and object control skills. Space covering skills include different forms and kinds of rolling, looping, crawling, walking and running that help us cover distances on different kinds of surface, tilts and in different directions. Surmounting obstacles skills are comprised of different kinds and forms of crawling through a narrow space, climbing, landing and jumping that help us overcome different kinds of vertical, diagonal and horizontal obstacles without using some technical or other kinds of devices. Resistance overcoming skills include a variety of forms of pushing, pulling, holding and carrying that overcome the passive resistance of objects that have different volumes and shapes and forms of individual or group resistance that overcome unforeseeable active dynamic forces of

people that take part in exercising. Finally, object control skills are comprised of different kinds of throwing and catching, targeting and shooting that enable us to operate simple and complex operations of handling the objects that differ in number, shape and volume in a particular space and time.

*The set of space covering skills tasks include:* chest crawling (time necessary to cover a 3.3 meters long area), back crawling (time necessary to cover a 3.3 meters long area), straight running (time necessary to cover a 20 meters long area), rolling sideways (time necessary to cover a 2.3 meters long area), changing course running (time necessary to cover a 12 meters long area with 2 course changes) and beam walking (time necessary to cover a 4 meters long, 15 cm high and 30 cm wide beam by walking to the end of the beam and back – repeat if anyone falls).

*The set of surmounting obstacles skills tasks include:* running across obstacles (time necessary to surmount a 15 meters long area across 3 obstacles), skipping across obstacles (time necessary to surmount a 20 meters long area across 4 obstacles), crawling through obstacles (time necessary to surmount a 12 meters long area through 2 obstacles), single-leg hops (time necessary to surmount a 10 meters long area without floor contact of the non-preferred leg), climbing the Swedish bars (time necessary to accomplish a single climb up and down the bars) and jumping over and through obstacles (time necessary to surmount 3 jumps and 3 crawling through obstacles).

*The set of resistance overcoming skills tasks include:* rolling a tube backwards (time necessary to cover a 6 meters long area moving backwards), carrying the medicine balls (time necessary to cover a 3 meters area carrying a 3 kg medicine ball 2 times), carrying the BOSU (Pilates) ball around cones (time necessary to cover a 7.5 meters long area with a 3 kg ball), rolling the ball around cones (time necessary to cover a 6 meters long area), pulling the bag (time necessary to pull the 5 kg bag for 6 meters) and lifting the medicine ball onto a table (time necessary to lift 3 medicine balls of 3 kg onto a

table).

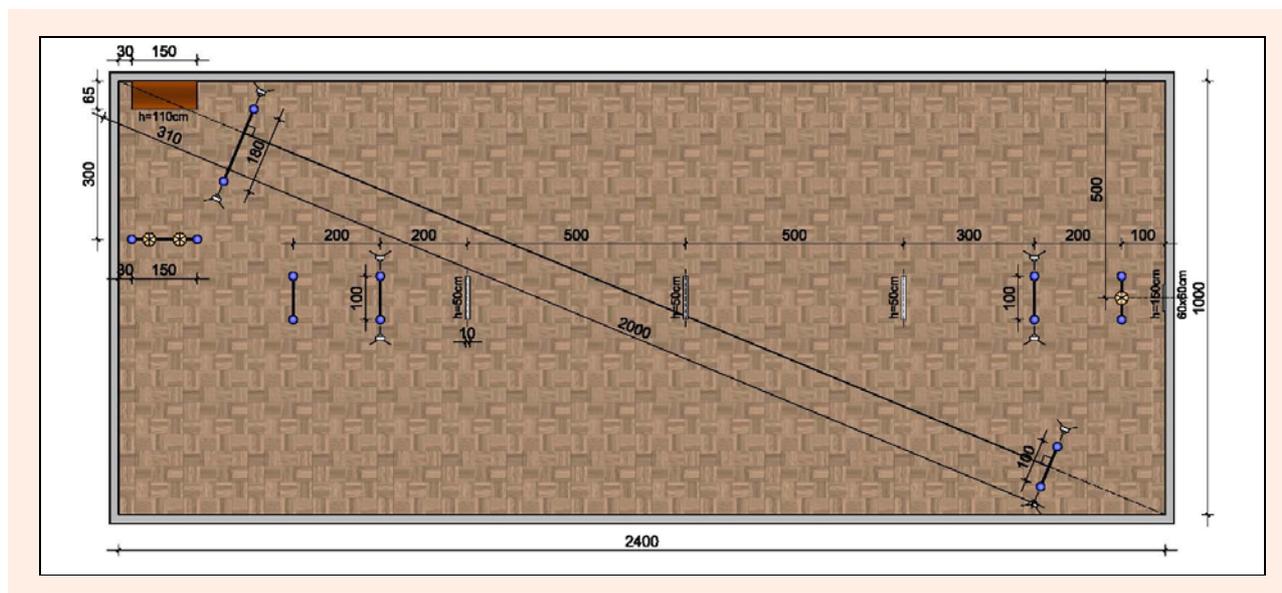
*The set of object control skills tasks include:* rolling the ball by hand to a wall (time necessary to accomplish 6 repetitions in a row), dribbling the football around cones (time necessary to cover a 6 meters long area), rolling the handball around cones (time necessary to cover a 6 meters long area), dribbling the handball around cones (time necessary to cover a 6 meters long area), tossing and catching the tennis ball against a wall (time necessary to accomplish 5 tosses and catches in a row) and tossing and catching a volleyball against the wall (time necessary to accomplish 6 tosses and catches in a row).

Norms of equipment (height of obstacles, weight of medicine balls, running distances etc.) used in all tasks were adopted from the official curriculum of the Croatian physical education program (Findak et al., 1998). The standard equipment norms are as follows: a 3 kg heavy medicine ball, 50 cm high sponge obstacles and 20 m long running distance. In the tasks that include running photocells were used to assess the time more accurately.

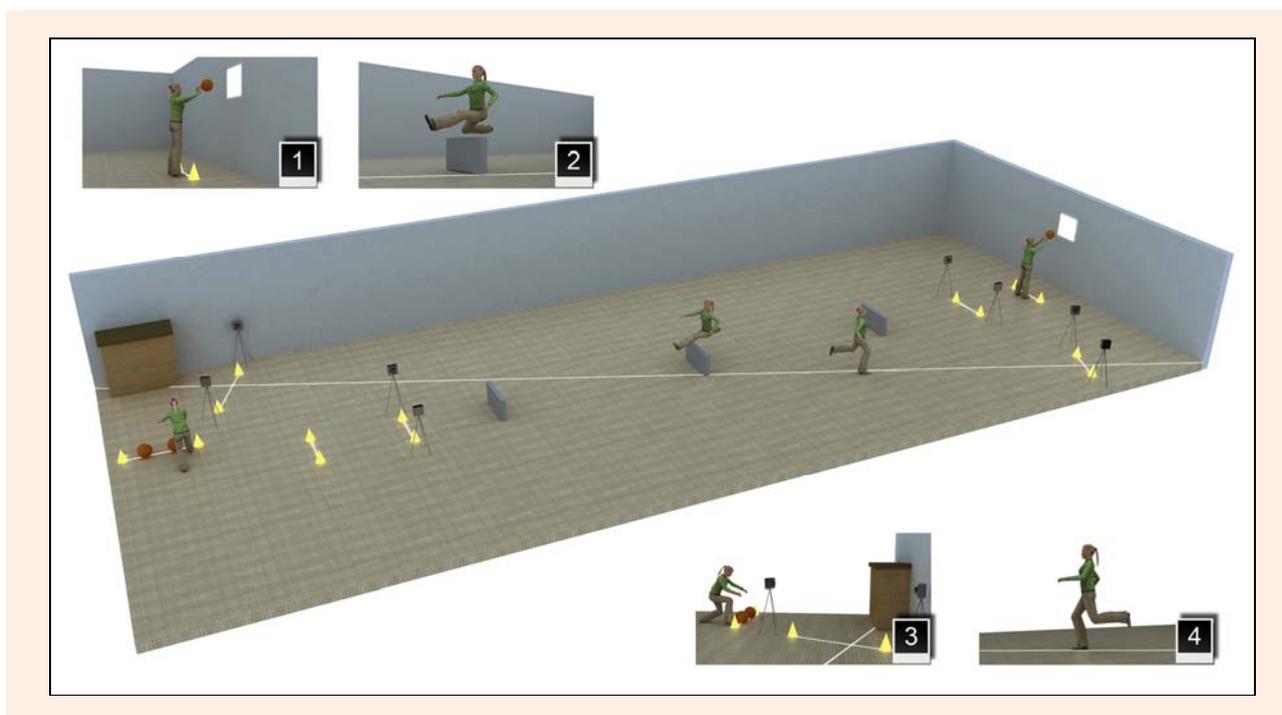
The Kolmogorov–Smirnov test was conducted to assure that all of the 24 tasks have normal distributions. The results revealed that three tasks do not have the expected distributions and therefore were excluded from further analysis: back crawling, climbing the Swedish bars and dribbling the handball around cones.

*Polygon – the final fundamental movement skills assessment tool (FMS-POLYGON):* The FMS-POLYGON consisted of 4 of the previously mentioned 21 tasks (one from each movement skills area): tossing and catching a volleyball against the wall consecutively; running across obstacles; carrying the medicine balls; and straight running. An area of 10x24 meters, 14 cones, 3 obstacles, 2 medicine balls, a volley ball, a Swedish vault and 4 pairs of photocells are needed for the FMS-POLYGON execution (Figure 1).

The participants' task is: to stand on a starting line with the volleyball and begin the first task of tossing and catching a ball against the wall 6 times on the examiner's signal; to leave the ball and run across three obstacles



**Figure 1.** A ground plan of the sports hall for FMS-POLYGON execution with measures and dimensions included.



**Figure 2.** A 3D sketch of the FMS-POLYGON with separate fragments of the test displayed.

finally passing through the cones; to lift and carry the first and the second medicine ball and put them on the Swedish vault; to run 20 meters until passing through the photocells. It is important to emphasize that the middle obstacle has to be moved aside before the run which is the assistant's task. The result of the test is the time needed to successfully accomplish the four mentioned tasks (Figure 2).

*"Test of Gross Motor Development" (TGMD-2):*

The purpose of the TGMD-2 is to measure the level of FMS in children from 3 to 10 years of age (Ulrich, 2000). The test is composed of two subtests (locomotor skills subtest and object control skills subtest) with each subtest comprising six skills. The six skills that comprise the locomotor subtest are: run, gallop, hop, leap, horizontal jump and slide. The six skills that comprise the object control subtest are: striking a stationary ball, stationary dribble, catch, kick, overhand throw and underhand roll. All skills have a set of 3 to 5 criteria (depending on a test) and every criterion is assessed using a 0 or 1. The child repeats every skill twice, so the maximum score for every skill can be from 6 to 10. According to the previous research (Catenassi et al., 2007; Niemeijer et al., 2007; Houwen et al., 2007; Simons et al., 2008; Mazzardo, 2008; Evaggelinou et al., 2002, Wong and Cheung, 2007) this test is valid and reliable in school children and therefore was used in this study to investigate the concurrent validity of the newly constructed test - FMS-POLYGON.

**Data analysis**

Data were analyzed using the Statistica for Windows 7.0 package and the statistical significance was set at  $P \leq 0.05$ . Basic descriptive statistics were calculated (mean value and standard deviation). According to the partial aims stated we checked an aspect of reliability of the set of fundamental movement skills tasks and the FMS-

POLYGON. Intra-observer reliability was determined using ICC. Concurrent validity was estimated by examining Spearman Rho correlations ( $r$ ). The hypothesis was to be accepted when correlation coefficient exceeded 0.70.

The four factorial analyses, with the principle component method and varimax rotation were used to define the most appropriate task for each of the FMS subgroups defined by Mrakovic. The most appropriate task for the newly constructed polygon test should be the one in which characteristic factor values ( $\lambda$ ) and percentage of the common variance derived the most of variance explained (variance percentage) for each sub-sample group. The factors were considered significant when explained variance ( $\lambda$ ) exceeded 1. In this way the task with the highest projection on latent dimension were chosen to be part of the newly constructed FMS test.

**Results**

The ICC for the object control skills area ranged between 0.88 – 0.96 (Table 1). In surmounting obstacles skills area the ICC ranged between 0.92 – 0.97. The ICC in resistance overcoming skills area ranged between 0.83 – 0.94 while in the space covering skills area the same coefficients ranged between 0.89 – 0.95. The means of each task showed similar results with the longest task lasting 7.56 sec (*carrying the BOSU ball around cones*) and the shortest one lasting 3.31 sec (*rolling sideways*). According to the factorial analysis, in each movement area a single factor was extracted. *Tossing and catching a volleyball against the wall* had the highest projection in the object control skills area (0.84). *Running across obstacles* had the highest projection in the surmounting obstacles skills area (0.87). *Carrying the medicine balls* had the highest projection in the resistance overcoming skills area (0.86) and *straight running* had the highest projection in

**Table 1.** The results of the intra-rater reliability and the factorial analysis for the 21 newly constructed tasks.

	ICC	Mean ( $\pm$ SD)	F
<b>Object control skills</b>			
Rolling the ball by hand to a wall (sec)	.88	4.91 (.86)	.83
Dribbling the football around cones (sec)	.89	4.59 (1.24)	.72
Rolling the handball around cones (sec)	.89	4.04 (.73)	.81
Tossing and catching the tennis ball against a wall (sec)	.96	5.40 (1.35)	.83
Tossing and catching the volleyball against a wall (sec)	.92	5.57 (1.24)	.84*
<b>Surmounting obstacles skills</b>			
Running across obstacles (sec)	.96	4.91 (.59)	.87*
Skipping across obstacles (sec)	.97	4.74 (.54)	.82
Crawling through obstacles (sec)	.93	7.08 (1.00)	.86
Single-leg hops (sec)	.93	5.23 (.78)	.86
Jumping over and through obstacles (sec)	.92	6.34 (1.01)	.78
<b>Resistance overcoming skills</b>			
Rolling a tube backwards (sec)	.85	4.62 (.79)	.67
Carrying the medicine balls (sec)	.90	5.33 (.59)	.86*
Carrying the BOSU ball around cones (sec)	.94	7.56 (.94)	.70
Rolling the ball around cones (sec)	.92	5.35 (.74)	.78
Pulling the bag (sec)	.83	6.31 (.98)	.57
Lifting the medicine ball onto a table (sec)	.94	5.96 (.89)	.75
<b>Space covering skills</b>			
Chest crawling (sec)	.93	3.57 (.75)	.82
Straight running (sec)	.95	4.53 (.31)	.83*
Rolling sideways (sec)	.89	3.31 (.70)	.77
Changing course running (sec)	.92	4.07 (.41)	.71
Beam walking (sec)	.94	5.88 (1.34)	.69

\*tasks with the highest projections that were later inserted in the FMS-POLYGON

the space covering skills area (0.83). According to the results obtained, those tasks were inserted in the FMS-POLYGON.

ICC for the FMS-POLYGON showed a very high result (0.98) and confirmed the test's reliability (Table 2). Mean score for the FMS-POLYGON was 24.20 while the mean score for the TGMD-2 was 59.45. Correlation analysis between the newly constructed FMS-POLYGON and the TGMD-2 revealed the coefficient of -0.82 ( $p < 0.05$ ) which indicates a high positive correlation because lower performance time in FMS-POLYGON test means better result, unlike the TGMD-2.

**Table 2.** The results of the intra-rater reliability and the correlation analysis for the newly constructed and previously validated test.

	ICC	Mean( $\pm$ SD)	r
FMS-POLYGON (sec)	.98	24.20 (2.43)	-.82
TGMD-2		59.45 (15.25)	

## Discussion

The need for a quick and easily administrable test for FMS assessment has been noted among the primary schools. Once constructed, it is crucial that the new test is valid and reliable assessment instrument.

Results confirmed the intra-rater reliability of the newly constructed 21 multiple-item tasks due to high ICC values in all movement areas. If we compare these results with the test results of FMS assessment made by other authors with different measurement tools (Ulrich, 2000), ICC values for the 21 tasks are found to be very high. Reliability measures reported medium correlations (ICC = 0.70) for the "Movement Assessment Battery for Children" (M-ABC), high correlations (ICC = 0.97) for the

"Körperkoordinationstest für Kinder" (KTK) and high correlations (ICC = 0.92 to 0.97) for the "Maastrichtse Motoriek Test" (MMT) (Cools et al., 2008). The highest intra-rater reliability was observed in the surmounting obstacles skills area while the lowest, but still high, intra-rater reliability was noted in the resistance overcoming skills area. These findings might be related with the type of the participant's organized physical activities. It is obvious that only a small number of children have developed resistance overcoming skills, therefore, those tasks were somewhat new to the majority of the children. On the other hand, most of the children participate in the locomotor (space covering and surmounting obstacles) skills, so children were familiarized with those tasks and the intra-rater reliability was the highest. Furthermore, children's free time activities spent outdoors are not negligible. Traditional games that children of this region play mostly have the potential of developing space covering and surmounting obstacles skills while resistance overcoming games are rare and uncommon.

The mean scores of the 21 tasks reported similar results. The similarity of the performance time for each task was respected during the construction of the tasks. In order not to favor a certain task it was important to approximately equally time all the assessment instruments.

Results of the factorial analysis yielded the identification of a single factor. The best representatives of every movement area were recognized and inserted in the final test – FMS-POLYGON. The tasks *tossing and catching a volleyball against the wall*, *running across obstacles*, and *straight running* have a lot of similarities with the TGMD-2 (Ulrich, 2000). The first one is similar to the TGMD-2's *catching 4-inch plastic ball*, only being performed against the wall. The second one is similar to the *leap* but with obstacles, and the third one is the same

as the TGMD-2's run. So, the tasks are practically identical but with an assessment difference. TGMD-2 is a criterion-referenced test while the FMS-POLYGON has a norm-referenced assessment. Studies encountered have been dealing with relations between the two assessments approaches (McIntyre, 2000; Robertson and Konczak, 2001; Miller, 2002). A general conclusion of the strong relationships existence between criterion- and norm-referenced assessments can be discovered in mentioned studies. The only task that cannot be compared is the *carrying the medicine balls*. That task belongs to the resistance overcoming skills area which has not been recognized in FMS classifications other than by Mrakovic et al. (1993). However, Gallahue and Donnelly (2003) state that the gross object control skills can be divided into categories: *giving force to objects* and *receiving force from objects*. The later can obviously be interpreted as resistance overcoming skills.

A high intra-rater reliability was noted when analyzing the newly constructed FMS-POLYGON with ICC value being similar to the one of Zimmer and Volkmer (1987) when validating the norm-referenced "*Motoriktest für vier- bis sechsjährige Kinder*" (MOT 4-6). When comparing the mean value of the TGMD-2 of this study with some that were previously published (Mazzardo, 2008), we noted that the results are somewhat similar suggesting that there is no or little impact of cultural differences at this age.

A very important goal of the study was to examine the concurrent validity of the FMS-POLYGON using the TGMD-2. Pearson's product correlation coefficients ranged between 0.60 and 0.90 between the M-ABC and the BOT-2 (Croce et al., 2001) and 0.62 between the M-ABC and the KTK (Cools et al., 2008). In the present study correlation between the FMS-POLYGON and the TGMD-2 was high, so hypothesis that the newly constructed FMS polygon will make valid measurement can be accepted. Based on these results it can be assumed that a participant's success in one test (TGMD-2) can be predicted according to the result in the other one (FMS-POLYGON).

Although the complete FMS-POLYGON task includes some of the motor fitness components (agility, endurance) that are not considered to be fundamental movement skills, authors are of the opinion that it could not have been avoided. Since motor performance ability can be understood as an interrelationship of a number of functional factors (Lämmle et al, 2010) it cannot be extracted from a single FMS assessment test. The confirmation can be found in the presence of agility in the *slide* task or the presence of explosive strength in the *leap* task of TGMD-2 which is considered to be a FMS assessment tool.

Finally, a construction and validation of a norm-referenced FMS test for easy and precise assessment of those skills in 8 year old children adds a great dimension to this research. Gathered scientific facts can be of great use to sport scientists, physical education teachers and other experts involved in the FMS performance assessment of young school children. For future validation it would be advisable to compare it with other verified FMS tests with norm-referenced assessment such as BOT-2.

## Conclusion

In conclusion, given the need for a quick and efficient FMS assessment tool, the present study sought to construct and investigate the validity of the FMS-POLYGON. Findings from the present study suggest that FMS-POLYGON is a reliable and valid instrument for 8 year old children. Limitations of the test can be manifested due to the lack of qualitative assessment for more precise evaluation of the skill acquisition. This could be the aim of a future research which should involve videotaping and qualitative judgment of the skills according to the defined criteria along with the time measuring.

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## Key points

- All 21 newly constructed tasks demonstrated high intra-rater reliability (0.83-0.97) in FMS assessment. High reliability was also noted in the FMS-POLYGON test (0.98).
- A high correlation was found between the FMS-POLYGON and TGMD-2 which is a confirmation of the new test's concurrent validity.
- The research resolved the problem of long and detailed FMS assessment by adding a new dimension using quick and effective norm-referenced approach but also covering all the most important movement areas.
- New and validated test can be of great use primarily in school practice for physical education teachers and FMS experts.