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ABSTRACT:

Purpose: The number of familiarization sessions in fitness assessments seems to be critical and inconsistent. Therefore, the primary aim of this research was to determine the number of familiarization attempts that stabilize the results in particular physical fitness tests. The secondary aim was to establish the test reliability through familiarization sessions. **Methods:** Thirty-nine primary school children participated in this research (age: 10.8 years, body mass: 40.6±8.9 kg, and body height: 145.3±7.2 cm). During six sessions, with one session every third day, participants performed the following tests to assess explosive strength (vertical jump and standing long jump), coordination (polygon backwards and polygon with turn*)* and flexibility (toe touch). **Results:** The results of repeated analysis of variance (ANOVA) showed that there were significant increases ($p<0.05$) in the polygon backwards and polygon with turn performances from the first to third familiarization session. The standard error of measurement decreased as sessions progressed, indicating little within subject variation between the coordination test results following a familiarization period. Statistically significant differences were identified in the vertical jump test from the fourth test session compared to the first session. On the other hand, statistically significant differences for the standing long jump test were only found in the final session compared to the initial session. In the toe touch test, there were no significant increases from the first to the final familiarization session. All tests showed high α reliability coefficients, ranging from 0.979 to 0.991. **Conclusion:** Polygon backwards and polygon with turn performance may be a practical, reliable method to assess coordination in primary school-aged children. However, completion of at least 3 practice sessions is suggested for participants to obtain a stable score. In addition, both jump tests are feasible for assessing skill-related fitness in young children, although the scientific reliability of the two tests should be questioned and the tests should be tailored to fit the age group of the children.

Key words: motor abilities, learning, primary school, reliability

Introduction

Physical fitness in children and adolescents has been linked to fitness, physical activity and health outcomes in adulthood (16). Moreover, evidence indicates that childhood fitness is important for childhood health (4). Therefore, practicing fitness assessments in children provides extremely valuable information (17). Field tests are frequently used to measure the levels of physical fitness (29). However, there has been considerable debate about the inherent value and utility of coordinated fitness testing in schools (25). In addition to the mentioned controversy, there is discussion whether fitness testing is related to physical fitness in children and youths and whether it has a positive impact on physical education in schools (7). Accordingly, Burton and Miller (2) have provided several reasons for the assessment, which include identification and categorization, planning medical treatments or activities, assessing changes over time, giving information to the person who exercises, and predicting progress. In addition, a recent systematic review noted that assessing physical fitness in the youth has become highly relevant for clinical and public health (23). However, testing children's physical fitness and monitoring their development is complex, requiring a high level of precision, reliability and objectivity (28). Moreover, numerous factors are likely to impact the reliability of the test results. The complexity of children's motor skills and use of the same protocols and tests impose the question of the point at which the test result represents the accurate ability level. In addition, Baumgartner (1) stated that if the result from an initial assessment was obtained before individual performance stability, the difference in the final assessment could be attributed to faster test performance learning than to experimental treatment. Accordingly, new methods and tests are needed to assess a child's physical fitness and the influence of familiarization on the entire result of the single test.

Familiarization attempts enable participants to become familiar with the task through trial attempts and within the period of 48 hours, while preventing the influence of learning on the results (20). Research studies concerning the influence of familiarization on physical fitness test results have been conducted by several authors (8, 10, 28). Tsigilis and Theodosiou (29), and more recently Tomac et al. (28), found a positive influence of familiarization on the test results. Moir et al. (20) concluded that familiarization is not necessary to achieve a high level of reliability in vertical jump tests. However, if the motor task is complex, task repetition has an important influence on the learning process (13). Lorger et al. (18), working with a group of students, tried to determine the influence of learning on the standing long jump and discovered that task understanding and repetitions significantly improved the result. In additional, Sporis et al. (27) tried to determine whether appropriate motor skill assessment tests for the motor reaction and speed of motor learning process in students are those in which the same movement is repeated several times. The aforementioned authors discovered that the acquisition of new motor skills as well as motor program development are related to both complex motor structures and familiarization with the motor task.

In the past, it has been argued that physical fitness should not be assessed because it was not previously demonstrated to be related to childhood health (17). However, a recent debate of fitness testing in schools may have increased focus on the importance of providing schools and teachers with appropriate guidelines and strategies for effectively using physical fitness testing. (25). Physical fitness needs to be accurately assessed to better understand its relationship with health in children. Accordingly, sport practitioners do not have sufficient information about possible distractors in testing or about which physical fitness tests should be used in field-based conditions for evaluating children. Therefore, the primary aim of this research was to assess the need for and, subsequently, the number of helpful, familiarization attempts to stabilize the physical fitness test results. The secondary aim was to establish the test reliability through familiarization sessions.

Methods

Participants and Procedures

This study was conducted on a sample of 60 children in the fourth grade attending primary school in Sisak, Croatia. Thirty-nine pupils (age: 10.8 years, body mass: 40.6±8.9 kg, and body height: 145.3±7.2 cm) participated in the full research study, including 16 boys (body height: 143.1±6.2 cm and body mass: 39.4±8.3 kg) and 23 girls (body height: 146.9±6.4 cm and body mass: 41.8±7.6. kg). Anthropometric measurements (height and weight) did not show any significant differences between the boys and girls. Parental consent and child assent were also obtained. Children with any physical disability or health condition that prevented completion of any of the fitness tests were not allowed to participate in testing. The study protocol was approved by the Ethical Committee of the Faculty of Kinesiology, University of Zagreb, according to the revised Declaration of Helsinki. The school board also confirmed that this research complied with ethical principles guiding scientific research in human subjects. All tests were performed in a school gymnasium during participants' normal physical education time.

The research consisted of assessing the physical fitness abilities in 6 testing protocols with a 48-72-hour interval between each session. After initial testing, pupils were given feedback during 4 sessions of transit testing. The feedback consisted of information about the results and movement techniques in a setting of motivational encouragement. During the sessions, the participants were given qualitative demonstrations and instructions as preparation for the physical tests. Participants were exposed to six sessions with one session every third day. Three attempts were conducted in every session. After every repetition, participants were given feedback, and each of the achieved scores was recorded. The only feedback that the pupils received in the final test was the result. The mean values for three results in the session were used in the analysis.

Testing

The testing procedure was preceded by a 5-minute warm-up, which included 5 exercises of different joint rotations (head, shoulders, hips, knees and ankles) and some elementary games for children in this age group. The subjects were divided into smaller groups to perform the motoric tests, and they stayed in these groups during the entire assessment. All measurements were performed by five experienced evaluators, one at each testing station. The tests for the physical fitness ability assessment used in this research were the following: polygon backwards, polygon with turn, standing long jump, vertical jump and toe touch.

Coordination was measured using a two polygon tests that included fundamental motor skills (backward and forward crawling). The reasons for choosing these two tests were twofold. First, according to the authors' knowledge, the only available national fitness test battery is the western Balkans country evaluation, which includes aforementioned tests. Additionally, there was a need to determine the effects of familiarization on the tests that focused on skill-related fitness. From the public heath perspective, according to Williams et al. (31), lower motor proficiency is associated with lower levels of physical activity. According to the authors' knowledge, pupils were not involved in similar exercises through their physical education curricula. Therefore, it would be interesting to determine whether there are confounding factors affecting the test performance, especially factors that greatly depend on motor skill levels.

The standing long jump and vertical jump field-tests are commonly used to assess explosive muscular strength in youth. Moreover, most national test batteries include the aforementioned tests. Despite the widespread use of these batteries, their validity is not clear (3). However, these tests are feasible compared to the squat jump and counter-movement jump evaluations, especially when they are used in school settings and population-based studies. It would be of interest to better understand the factors that can confound field-based testing, such as familiarization.

The toe-touch test was chosen because of its simple administration. The test requires very little instruction or training and can be used to test a large number of students in a short period of time (11). During the toe touch test, individuals are assessed while standing instead of sitting on the floor, as in the classic sit-and-reach test. The test's validity and reliability has been demonstrated in several other studies (19).

Polygon backwards. The subject had to crawl backwards and cover a 10-m distance. The starting position for the children was behind the starting line as the children faced backwards on all fours. The tester gave the starting signal. The test included backward crawling (A) over and (B) under the 35 cm high obstacles that were placed at (A) 3 meters and (B) 6 meters from the starting line. The task was measured in tenths of a second (0.1 s) (26).

Polygon with turn. The starting position for the subject was behind the starting line while facing forward on all fours. The tester gave the starting signal. The subject had to crawl and cover a 9-m distance. The test included forward crawling for the first three meters and then turning backwards and crawling backwards to the 6 m mark. At the 6 m mark, subjects must crawl backward under the 35-cm high obstacles, finishing backwards on the 9-m mark. The task was measured in tenths of a second (0.1 s) (22).

Standing long jump. The starting position of the subject was the counter movement jump. The subject jumped with both feet from the reverse side of the Reuter bounce board onto the carpet, which was marked in cm. The result was recorded as the length of the jump in centimeters (6).

Vertical jump. The subject stood on the side and reached up with the hand closest to the wall. Keeping his or her feet flat on the ground, the point of the subject's fingertips was marked or recorded, which was called the standing reach. The subject then stood away from the wall and vertically jumped as high as possible using both arms and legs to assist in projecting the body upwards. The subject attempted to touch the wall at the highest point of the jump. The difference in the distance between the standing reach height and jump height was given as the score.

Toe touch. To perform the test, the subject stood on the 40-cm high box with his or her feet hip-width apart. The subject's legs were straight and feet were parallel. The subjects were instructed to bend as far forward as possible, while keeping their knees, arms and fingers fully extended. The subject remained in the final position for two seconds. Scores were recorded in centimeters to the nearest 0.5 cm using the scale on the left side of the reach indicator. The toe touch distance was determined by measuring the distance from the end of the right middle fingertip to the tip of the toes. A negative value was indicated as failure to reach his or her toes. (19).

Statistical analysis

The basic descriptive parameters were calculated. Normality of the distribution was tested with the Kolmogorov-Smirnov test. The comparison between the results on different days was performed using ANOVA for repeated measures and through the multiple comparisons test by Bonferroni to specify which of the measurements differ between each other. As a method of internal consistency, Cronbach's alpha was used to determine the reliability inside the series of measurements, as well as the variability coefficient. Additionally, the average correlation between the units (AVR) was used as the measure of homogeneity. The interclass correlation coefficient (ICC) and analysis of variance were used to determine the reliability between the series of measurements. Data analysis was performed using the Statistical Package for the Social Sciences (v13.0, SPSS Inc., Chicago, IL, USA). Statistical significance was set at $p<0.05$.

Results

Data normality was verified for all variables using the Kolmogorov-Smirnov test. The mean values (±SD), as well as the magnitude (minimal and maximal values), of the results according to the explosive strength tests in six test sessions are presented in Table 1. Statistically significant differences were identified in the vertical jump test from the fourth test session in relation to the first session ($p<0.05$). On the other hand, statistically a significant difference for standing long jump test was only found in the final session ($p<0.05$). The reliability α coefficients for both explosive strength tests were high and varied between 0.95 and 0.98 (Table 1). The vertical jump and standing long jump tests also had a high AVR (average inter-trial correlation). The within-subject variation (CV) in both jumping tests ranged between 11.53 and 19.03 for all sessions.

ANOVA results showed that there were significant increases ($p<0.05$) in polygon backwards and polygon with turn tests from the first to the third familiarization session. However, session differences were reduced to nonsignificant levels ($p>0.05$) when the test results between sessions 2 and 3 were compared, showing that the results stabilized between sessions 2 and 3 for both exercises. The typical measurement error and CV for both the polygon backwards and polygon with turn tests are presented in Table 1. These show that typical error decreases as the number of sessions increases, which increases the reliability α coefficients for coordination tests. The results for Cronbach's alpha varied between 0.93 and 0.98 for the polygon backwards test. The results were similar for the polygon with turn test (0.95-0.99). The CV was high for both the polygon backwards (21.69-58.50%) and polygon with turn (24.46-43.03%) tests. However, there was a trend of decreasing CV for both tests during the testing sessions (Table 1).

In the toe touch test, there were no significant increases from the first to the final familiarization session ($p>0.05$). The results for Cronbach's alpha were high, ranging from 0.96 to 0.98.

Discussion

The primary aim of this research was to determine the need for, and number of, familiarizing attempts that stabilized the test results for assessing the explosive strength, coordination and flexibility for primary school pupils. The testing results indicated that familiarizing attempts during the performance and introduction of fitness tests significantly improved the results in the coordination tests. Given that pupils did not participate in any intervention program, the improved performance may be attributed to the mere execution and familiarization with the test. However, the number of familiarization sessions seems to be critical to increasing the precision of fitness assessments. The importance of familiarization trials for attaining more accurate results in physical fitness tests among children has recently been reported in other studies (5, 9, 18, 28, 29).

The standing long jump and vertical jump tests are field tests that are commonly used to assess the lower body explosive muscular strength in youths (3). However, despite their widespread use, their validity and reliability is not clear. Moreover, there is controversy over the need for familiarization in jumping tests. Nibali, Tombleson, Brady, & Wagner (21) stated that the vertical jump test can be performed without requiring familiarization trials. This test may not require familiarization trials because most of children perform related motor skills by default and are thus familiar with vertical jump-related tasks. Furthermore, children's free time spent outdoors is not negligible. Traditional games that the children in this region play can foster their jumping skills. In addition, according to Baumgartner (1), the amount of practice to produce stable scores depends on the test difficulty, participant age, and previous test experience. Tests that are simple to execute, such as the standing long jump in which performance is mainly determined by physical abilities, seem to yield more stable results than other motor tests. Therefore, our results for the standing long jump could be questionable. It could be argued that improvements in the standing long jump (Table 1) were from the training effects, especially considering that the improvement was significant in the final session compared to the initial session. Our results showed that reliability α coefficients for both explosive strength tests were high and varied between 0.95 and 0.98. Van Praagh and Franca (30) examined the validity of the standing broad jump test and reported that the test is objective and reliable; however, its validity is questionable. The aforementioned authors argued that the test does not measure a single factor, such as the power; instead, it evaluates several variables that influence performance, such as coordination and maturation. One study showed that the muscular strength during repetitive 1-RM tests is variable in prepubescent boys and the ability to produce maximal strength in this population seems to highly depend on a specific familiarization process. Similar results were obtained for the standing long jump in pre-school children (28), as well as in students (5), in whom the authors examined the influence of familiarization with the throwing a medicine ball overhead test. Moreover, the considerable number of repetitions, at the cognitive level, may influence the effective result in the Standing long jump as well as improve neuromuscular coordination (27).

Our findings showed that participants had decreased mean values across consecutive measurements, indicating improvement in the coordination test performance. Three sessions were required to stabilize the results in the polygon backwards and polygon with turn tests (Table 1). The scores on both tests continued to plateau after the third session; however, they lacked statistical significance. There was a small increase in the mean performance from trial 4 to 5 in the polygon backwards test. This variation in time may indicate that participants modified their movement patterns to maximize the results in response to their lack of familiarity with the movement pattern. The typical error of measurement and CV% decreased as the number of trials increased, which revealed better reliability of the coordination tests. Similar results were found for the reliability scores in the coordination test for children (KTK test) in a similar age group; the reliability coefficients ranged from 0.60–0.99 and Cronbach's alpha was 0.95 (12). Moreover, Zuvela, Bozanic and Miletic (32) showed that the fundamental movement skills (FMS) -POLYGON is a reliable, valid instrument for 8-year-old children. One study showed a very high coefficient of variation for several test items (67% for flamingo balance and bent arm hang), which was similar to our results and indicated that test items with a high CV were too complicated to evaluate at this age (7). However, these results might be related to the participant's default organized physical activities. It could be argued that the tasks in coordination tests are somewhat new to the majority of the children. Neural mechanisms in prepubescent children may lead to full muscle activation, better coordination of the synergistic and antagonistic muscles, or improvement in the movement coordination (15). Therefore, a learning effect may be encountered when using the polygon backwards or polygon with turn test to evaluate coordination, which suggests the necessity of at least three familiarization sessions.

Recently, a strong recommendation was reported for further research on the flexibility tests as well as for the consideration of the use of this fitness component in schools (24). The toe-touch test was chosen because of its simple administration. This test requires very little instruction and training, and it can be used to test many students in a short time period (11). The results of a recent meta-analysis (19) showed that the toe touch test had a moderate-high mean correlation coefficient for the criterion-related validity for estimating the hamstring extensibility in children (r=0.78, 0.65-0.92). Our study showed that the toe test can be performed without requiring familiarization trials. Introducing the test stabilized the result, which showed no significant differences between trials (Table 1). Flexibility is an ability with a low level of hereditary influence; also, the task simplicity and age of the children was favorable for developing new capabilities, which further interacted with the number of testing attempts, contribution of recognition, and stability of the results. However, the lack of data on biological maturation indicators has resulted in a high CV% in the Toe Touch test, which can be considered as a limitation.

The main findings in our study were that coordination test stabilization occurred at the third familiarization session for both the polygon backwards and polygon with turn tests. This is of great importance, especially considering that coordination is an important fitness ability in combination with speed and explosive strength (14). Additionally, some attempts are required to introduce the test. The present study showed that the polygon with turn and polygon backwards can be used with high reliability in fourth grade pupils. Moreover, given that the pupils did not participate in any intervention programs, the performance improvement should be attributed to the mere execution and familiarization with the test. Therefore, teachers and coaches should introduce children to the aforementioned tests during at least 3 sessions to obtain the best results and achieve result stability. Children should have sufficient information about the task to acquire test familiarity, allowing them to realize their maximum potential. Future studies should be conducted in pupils from the first to third grade to investigate whether the same tests are usable and if the tests results would demonstrate the same reliability. The number of familiarization sessions seems to be still critical to increasing the precision of jumping ability assessments. It can be speculated that a learning or practice effect may be encountered when using the vertical jump and standing long jump as a test of explosive power. An examination of whether vertical and horizontal jump scores continued to plateau after the sixth session is desirable. Therefore, both jump tests are feasible for assessing the physical fitness in young children, although the scientific reliability of the two test items should be considered, and the test items should be tailored to the age groups of the children under study. Most physical fitness test changes in young individuals who are following different training programs are attributed to the effectiveness of selected programs; however, they may instead be the result of initially inadequate testing. Moreover, children use and process information in different ways than adults, which may contribute to the need for repeated feedback information. Providing familiarization and feedback information when introducing tests could remove the learning effect, stabilize the results, and enhance the measurement instrument's reliability.

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Table 1. Basic descriptive parameters and reliability in all fitness tests

Variable	Mean±SD	Min	Max	α	AVR	CV	SEM
Initial vertical jump	23.15±3.83	13.00	32.67	0.962	0.911	16.54	0.61
Session 2	25.74±4.76	15.33	38.00	0.977	0.938	18.49	0.76
Session 3	25.54±4.69	17.00	39.00	0.976	0.946	18.38	0.75
Session 4	26.40±4.05*	19.67	34.67	0.977	0.937	15.33	0.65
Session 5	26.29±4.52*	17.33	40.67	0.979	0.941	17.19	0.72
Final vertical jump	23.32±4.44	14.67	36.00	0.952	0.874	19.03	0.71
Initial standing long jump	130.80±20.82	86.00	178.00	0.903	0.814	15.92	3.33
Session 2	136.62±19.80	94.00	172.33	0.976	0.934	14.50	3.17
Session 3	136.72±18.38	98.33	170.67	0.972	0.925	13.44	2.94
Session 4	142.80±19.10	97.00	175.33	0.982	0.951	13.37	3.06
Session 5	140.28±18.33	105.67	177.00	0.967	0.921	13.07	2.94
Final standing long jump	144.66±16.68*	108.67	180.67	0.961	0.896	11.53	2.67
Initial polygon backwards	19.64±11.62	12.00	85.04	0.980	0.976	58.50	1.84
Session 2	16.28±5.39	9.48	44.46	0.984	0.954	33.14	0.85
Session 3	15.25±3.71*	8.17	31.86	0.933	0.831	24.34	0.59
Session 4	14.77±3.20*	8.46	26.99	0.960	0.902	21.69	0.51
Session 5	14.85±3.39*	8.33	27.87	0.976	0.941	22.80	0.54
Final polygon backwards	14.20±3.22*	8.12	26.83	0.975	0.930	22.67	0.51
Initial polygon with turn	12.49±5.38	6.83	39.77	0.977	0.951	42.40	0.84
Session 2	10.93±4.15	5.65	30.34	0.991	0.975	37.92	0.65
Session 3	9.67±2.62*	5.22	19.32	0.971	0.919	27.11	0.41
Session 4	9.94±2.91*	5.19	21.47	0.976	0.935	29.23	0.46
Session 5	9.56±2.43*	5.49	16.27	0.974	0.930	25.46	0.38
Final polygon with turn	9.29±2.40*	5.44	17.18	0.953	0.880	25.81	0.38
Initial toe touch	40.16±6.42	27.67	50.67	0.973	0.925	16.51	1.04
Session 2	39.33±6.92	26.00	51.00	0.982	0.946	17.59	1.11
Session 3	41.03±6.42	27.67	51.00	0.984	0.945	15.66	1.08
Session 4	42.32±6.60	25.00	51.67	0.983	0.944	15.60	1.08
Session 5	40.97±6.53	28.00	53.00	0.969	0.915	15.94	1.07
Final toe touch	42.14±6.33	28.67	53.67	0.971	0.918	15.01	1.06

Min.-minimum result; Max.-maximum result; α-Cronbach's alpha; AVR-average correlation between the units; CV-coefficients of variability; SEM standard error of the measurement; *p-value<0.05 vs. session 1.