ABSOLUTE AND RELATIVE RELIABILITY OF TESTS ASSESSING KINESTHETIC DIFFERENTIATION ABILITY IN YOUTH FEMALE VOLLEYBALL PLAYERS

Karla Đolo[1,2], Zoran Grgantov[1], Mirjana Milić[1]

[1]*University of Split, Faculty of Kinesiology*
[2]*University of Mostar, The Faculty of Science and Education*

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Abstract
The aim of this study was to determine absolute and relative reliability of tests for assessing kinesthetic-differentiation ability in youth Herzegovinian female volleyball players. The sample of 32 volleyball players were recruited from 3 volleyball clubs in Herzegovina. Participants were aged 11.23±0.67 years and had practiced volleyball between 6 to 48 months. For the evaluation of kinesthetic-differentiation ability of arms and legs, 2 tests were conducted (Šimonek, 2006): Target sitting throw test (TST) for assessment of kinesthetic-differentiation ability of arms and target standing broad jump (TSBJ) for assessment of kinesthetic-differentiation ability of legs. The reliability of these two tests between the first and the second measurement was assessed using a two-way mixed effects Alpha model of intraclass correlation coefficient (ICC). The standard error of measurement (SEM) was also calculated to give an indication of the precision of individual scores over repeated administrations (SEM = SD x √ 1 – ICC), and the smallest detectable change (SDC) for the interpretation of change in scores which is outside an error and which is due to a real change in score and not due to the error in measurement. To test the absolute reliability of the TST and TSBJ tests, the agreement between repeated measurements (test-retest) was quantified using the 95% limit of agreement (LoA) method originally described by Bland and Altman (1986).
Target sitting throw test for the assessment of kinesthetic-differentiation ability of arms and Target standing broad jump for the assessment of kinesthetic-differentiation ability of legs have a high (moderate, good) level of absolute and relative reliability. Thus, they can be recommended for testing the kinesthetic-differentiation ability of arms and legs in youth female volleyball players.

Key words*: TST and TSBJ tests, test-retest, ICC, SEM,SDC*

Introduction

Two columns, Verdana 9 normal, space 1 Volleyball is a sport which requires perfection of various specific technical skills. High-level performance of those techniques is related to competitive efficacy of volleyball players (Katić et al., 2006). The level of coordination abilities affects technique in all stages of sport training (Brođani & Šimonek, 2010). Coordination abilities are important for perfecting technique and tactics, as well as applying them in unfamiliar circumstances. Adequate coordination level in children is important for their general development (Vandorpe et al., 2011a.). Therefore, it is important that coordination develops during childhood, following the sensitive periods, more specifically from the age of 6 to 12 years (Hirtz et al., 2002). Vandorpe et al. (2011b.) determined that motor coordination is the most important factor in discriminating between young female elite and sub-elite gymnasts. Pion et al. (2015) concluded that motor coordination is an important factor in determining inclusion into the elite level in female volleyball. These findings demonstrate that high skill levels and general motor coordination are indeed performance-related factors affecting success during sports competition. There are several battery tests for assessing coordination, e.g., Movement Assessment Battery for Children (MABC), and Körper koordinations test für Kinder (KTK). These test batteries are utilized to identify children with motor difficulties now known as developmental coordination disorder (Junaid et al., 1998; Flapper et al., 2006; Schoemaker et al., 2008; Rosblad et al., 1998). KTK is also used as a predictor of physical activity level in children and as prognosis of future sport success (Iivonen et al., 2016), but it does not encompass all components (factors) of coordination which are important for successful performance in sport. Kinesthetic-differentiation ability is one of the components of coordination encompassed by the KTK test battery. It can be defined as the ability to control movements in time, space and dynamics, which allows for reaching high precision and fine harmonizing of individual phases, as well as movement activities as a whole (Brođani & Šimonek, 2010). In previous studies, this component was proven to be one of the most important for successful performance in wrestling (Lech et al., 2011) and tennis (Zetou et al., 2012). In sports games such as volleyball, kinesthetic-differentiation ability allows for realizing an accurate

pass or hit to a certain distance, to perform a jump for a spike, heading in a correct time and on a correct spot, to carry out movements in a correct spatial and temporal flow, etc. (Šimonek, 2006; Brođani & Šimonek, 2010; Šimonek, 2014).

Šimonek (2014) suggested 2 tests for assessing kinesthetic-differentiation ability:

1.Target standing broad jump (TSBJ - kinesthetic-differentiation ability of legs)

2.Target sitting throw (TST - kinesthetic-differentiation ability of arms)

These tests were constructed and validated several decades ago on a sample of German (TSBJ), i.e., Polish children (TST). Thus, the aim of this study was to determine absolute and relative reliability of tests for assessing kinesthetic-differentiation ability in youth Herzegovinian female volleyball players.

Methods

Participants

The sample of 32 volleyball players were recruited from 3 volleyball clubs in Herzegovina. Participants were aged 11.23±0.67 years and had practiced volleyball between 6 to 48 months. At the moment of testing, their training regime was 2-3 hours per week.

Variables

For the evaluation of kinesthetic-differentiation ability of arms and legs, 2 tests were conducted (Šimonek, 2006): Target sitting throw test (TST) for assessment of kinesthetic-differentiation ability of arms and target standing broad jump (TSBJ) for assessment of kinesthetic-differentiation ability of legs. The tests were conducted on an indoor floor surface to control the environmental conditions such as temperature, wind and ground conditions. Children were tested in the afternoon, between 1 to 4 pm, in two sessions with a 14-day interval between the sessions in order to assess test-retest reliability. Both tests were demonstrated by the measurer. All children had one preparatory attempt. A warm-up was conducted before the testing, which included 10 minutes of jogging and mobility exercises. In the TSBJ test, a participant jumps to a maximum distance 3 times. After marking the 75% distance of his maximal performance, the tested person tries to jump three times with his heels as close as possible to the given mark. An average of the three measured results is recorded. In the Target sitting throw test, a measurer stretches a measuring tape (50m long) on the floor surface. The tested person is sitting on the base line and throws a tennis ball 3 times to a maximum distance. The best result is recorded. In the second part of the test, the 50% of the maximum result is marked with a cone on the floor. The tested person throws other 10 attempts at the target on the ground. A deviation from the 50% mark is recorded.

Data analysis

All data were analyzed using the SPSS version 24 for Windows statistical program. Descriptive statistics including the mean, standard deviation (SD) and range value were calculated. The reliability of these two tests between the first and the second measurement was assessed using a two-way mixed effects Alpha model of intraclass correlation coefficient (ICC). In accordance with Cicchetti (1994), ICCs are considered excellent if >0.74, good from 0.60 to 0.74, fair from 0.40 to 0.59, and poor if less than 0.40. The standard error of measurement (SEM) was also calculated to give an indication of the precision of individual scores over repeated administrations (SEM = SD x $\sqrt{}$ 1 – ICC), and the smallest detectable change (SDC) for the interpretation of change in scores which is outside an error and which is due to a real change in score and not due to the error in measurement. Calculation of SDC relies on SEM and therefore SDC is also expressed in original units of measurement with a confidence of 90% or 95% (SDC95 = 1.96 x $\sqrt{}$2 x SEM) (Šerbetar, 2015). To test the absolute reliability of the TST and TSBJ tests, the agreement between repeated measurements (test-retest) was quantified using the 95% limit of agreement (LoA) method originally described by Bland and Altman (1986). To investigate systematic bias, t-test was conducted to test the hypothesis of no difference between the sample mean score for the test versus the sample mean score for the retest. Since heteroscedasticity was found in the present data, a logarithmic transformation was applied giving values that can be interpreted in relation to the original scale (Nevill and Atkinson, 1997). A repeated measures ANOVA was used to assess systematic bias between test items (Vincent and Weir, 2012, Thomas and Nelson, 2015).

Results

For the purpose of determining the reliability, the results of the mean scores in meters (m), SD values and ranges of the TST and TSBJ tests were analyzed (Table 1). The sensitivity of the tests was monitored through Kolmogorov-Smirnov test which showed that the obtained result distribution was not significantly different from normal distribution as *p* was not less than 0.05 (p>0.20). The Target sitting throw test had *skw 0.88* and *kur 1.08,* whereas the Target standing broad jump test had *skw 0.04, and kur -0.08.*

The results of ANOVA showed no statistically significant changes between items of measurements using Greenhouse-Geisser estimate of sphericity with the aim of detecting any systematic changes between items under the influence of fatigue, learning, or changes in motivation, thus, no further analysis with post-hoc tests was needed (Table 2), F_{TSBJ}=0.39; p=0.68, F_{TST}=1.32; p=0.24. Mean scores, SD values and ranges for the Target sitting throw test (TST) and the Target standing broad jump test (TSBJ) obtained during the first and second test session are presented in Table 3. There were no major differences between test sessions scores.

Table 1 *Descriptive statistics of the Target sitting throw test (TST) and the Target standing broad jump (TSBJ)*

	MEAN	SD	MIN	MAX
TST1	10.46	2.95	3.5	17.7
TST2	11.08	2.32	7.2	18.2
TST3	11.66	2.27	8.45	17.75
TSBJ1	1.38	0.22	0.89	1.83
TSBJ2	1.41	0.23	0.8	1.81
TSBJ3	1.42	0.22	0.85	1.84

Table 2 *Results of the analysis of variance*

	F	p
TSBJ	0.39	0.68
TST	1.32	0.24

Table 3 *Descriptive statistics of the Target sitting throw test (TST) and the Target standing broad jump (TSBJ)*

Test	Mean	SD	MIN	MAX
TST1	0.69	0.35	0.17	1.75
TST2	0.67	0.34	0.13	1.74
TSBJ1	1.04	0.17	0.67	1.4
TSBJ2	1.07	0.18	0.72	1.4

The test-retest reliability is shown in Table 4, indicating good intrarater reliability ICC (alpha) = 0.74 for the TST test, and excellent ICC (alpha) = 0.84 for the TSBJ test. The standard error of measurement (SEM) indicates that the measurement error was minimal, as well as the smallest detectable change (SDC). T-test was used to detect changes in the test-retest analysis in both tests, which yielded no significant differences between the measurements (p_{TST}=0.15; p_{TSBJ}=0.21).

A Bland-Altman plot illustrates difference scores between measurements against the mean score for each subject. The difference scores for the between-day measurement appear to spread evenly above and below the zero point. Intraclass Correlation Coefficient within items on the first day of measurement was (ICC_{TSBJ}=0.93; ICC_{TST}=0.60.

Table 4 *Test-retest reliability of the Target siting throw test (TST) and the Target standing broad jump test (TSBJ), with standard error of measurement (SEM), smallest detectable change (SDC), and t-test*

Test	ICC	SEM	SDC	t- score	p
TST	0.74	0.04	0.11	-1.49	0.15
TSBJ	0.84	0.01	0.03	-1.26	0.21

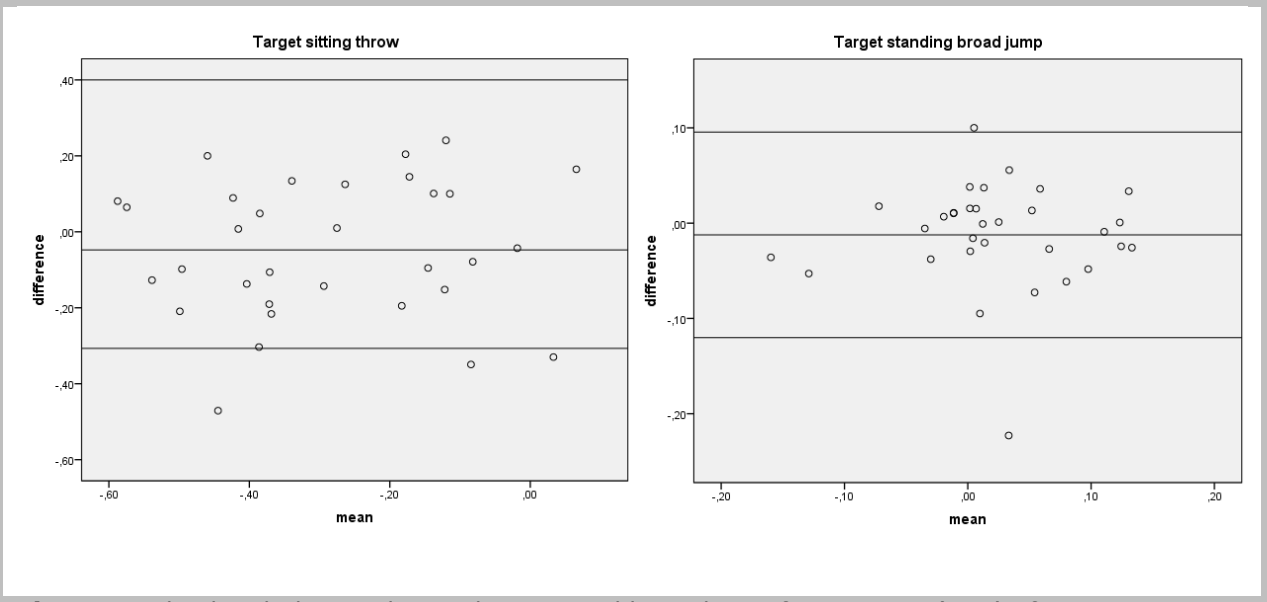

Figure 1. *Bland and Altman plots with upper and lower limit of agreement (LOA) of test-retest of the Target sitting throw test and the Target standing broad jump test. Mean – of test and retest score, difference(m) – between test and retest score(m).*

Discussion and Conclusion

This study examined the reliability of two coordination tests (Target sitting broad jump and Target standing throw) which assess kinesthetic-differentiation ability of arms and legs. The main finding of this study is that the TST test and TSBJ test are reliable outcome measures that can be used in monitoring kinesthetic differentiation ability in youth female volleyball players. There are different categories of agreement of interclass correlation coefficient with calculation ranging from questionable (0.70 to 0.80) to high (>0.90), as explained by Vincent and Weir (2012). The Target standing broad jump test demonstrated excellent test-retest reliability ICC=0.84, and the Target sitting throw test showed good test-retest reliability ICC=0.74. The most valid criteria of the structure of coordination capacities at the age of 14 years is kinesthetic-differentiation capacity of arms (Brodani and Šimonek, 2010). Therefore, it can be concluded why Target sitting throw reliability is lower at the age of 11. According to Portney and Watkins (1992), >0.75 should still be considered 'good'.

The SEM value is an estimate of measurement error and is used to calculate the SDC (Portney and Watkins, 1992). The SDC in this study indicates that the measurement error was minimal, and so is SDC. It can be noticed that the higher the interclass correlation coefficient, the smaller the SEM and SDC. Consideration of the SDC is important when monitoring the progress of athletes because intertrial variation may incorrectly suggest a change that has not exceeded the threshold of error (Beekhuizen, 2009).

Along with the ICC, the most appropriate and objective to assess reliability is the 95% LoA, limits of agreement method (Bland and Altman, 1986). The most recent studies investigating reliability of field-testing have used the ICC values and the 95% LOA method (Beekhuizen et al., 2009; Sassi 2009, Langley et al., 2017; Hachana et al., 2013). To identify the stability reliability of the TST and the TSBJ test, reliability was assessed as described by Bland and Altman (1986). In this study, there was high concordance between the scores of the TST and the TSBJ test, although the scores were scattered widely among them (Figure 1). In these analyses, after logarithmic transformations, data reducing heteroscedasticity bias and random error were found to be low, resulting in good reliability. The points were evenly dispersed above and below the horizontal mean line.

As with the t-test, ANOVA is useful for detecting large systematic errors. In this case, repeated-measures ANOVA revealed no statistical differences (p>0.05) between the test items.

In volleyball, the ability to control movements in time, space and dynamics is a very important coordination component. Development of kinesthetic-differentiation ability before puberty is an important precondition for quick and high-quality perfection of complex volleyball techniques later on in the career. Target sitting throw test for the assessment of kinesthetic-differentiation ability of arms and Target standing broad jump for the assessment of kinesthetic-differentiation ability of legs have a high (moderate, good) level of absolute

and relative reliability. Thus, they can be recommended for testing the kinesthetic-differentiation ability of arms and legs in youth female volleyball players.

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APSOLUTNA I RELATIVNA POUZDANOST TESTOVA ZA PROCJENU SPOSOBNOSTI KINESTETIČKE DIFERENCIJACIJE KOD MLADIH ODBOJKAŠICA

Sažetak

Cilj ove studije bio je utvrditi apsolutnu i relativnu pouzdanost testova za procjenu sposobnosti kinestetičke diferencijacije kod mladih odbojkašica. Uzorak od 32 ispitanice uključivao je odbojkašice iz 3 kluba u Hercegovini. Ispitanice su imale prosječno 11,23 ± 0,67 godina i vježbali su odbojku u prosjeku od 6 do 48 mjeseci. Za procjenu kinestetičke-diferencijacijske sposobnosti ruku i nogu provedena su 2 testa (Šimonek, 2006): Ispitivanje ciljanog sjedećeg bacanja (TST) za procjenu kinetičke-diferencijacijske sposobnosti ruku i ciljanog širokog skoka (TSBJ) za procjenu kinestetičko-diferencijacijska sposobnost nogu. Pouzdanost ova dva ispitivanja između prvog i drugog mjerenja procijenjena je primjenom dvosmjernog mješovitog efekta Alpha modela unutarčestičnog koeficijenta korelacije (ICC). Izračunata je i standardna pogreška mjerenja (SEM) kako bi se naznačila preciznost pojedinačnih rezultata tijekom ponovljenih primjena (SEM = SD x √ 1 - ICC) te najmanja izmjenjiva promjena (SDC) za tumačenje promjena rezultata koja je izvan pogreške i koja nastaje zbog stvarne promjene rezultata, a ne zbog pogreške u mjerenju. Da bi se ispitala apsolutna pouzdanost testova TST i TSBJ, između ponovljenih mjerenja (test-retest) kvantificiran je korištenjem metode 95% ograničenja dogovora (LoA) koju su izvorno opisali Bland i Altman (1986).

Ispitivanje TST za procjenu sposobnosti kinestetičke-diferencijacije ruku i TSBJ za procjenu sposobnosti kinestetičke-diferencijacije nogu imaju visoku (umjerenu, dobru) razinu apsolutne i relativne pouzdanosti te se mogu preporučiti za testiranje kod mladih odbojkašica.

Ključne riječi: *TST i TSBJ testovi, test-retest, ICC, SEM, SDC.*

Corresponding information:
Received: 29.10.2019.
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Correspondence to: Mirjana Milić
University: University of Split
Faculty: Faculty of Kinesiology
Phone +385989897780
E-mail: mirjanam@kifst.hr