Original Article

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Reliability and usefulness of the reaction speed test in young female volleyball players

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Abstract

Reaction speed represents a crucial ability to achieve a high-performance level in volleyball. A reliable computerized test for assessing reaction speed cannot simulate the dynamic environment of the volleyball game. Therefore, tests involving the activation of large muscle groups are needed. This study aimed to determine the reliability of young volleyball players' reaction speed ability using the Stopping the rolling ball test (SRB). Intraclass correlation coefficient (ICC), standard error of measurement (SEM) also expressed as a coefficient of variation (CV%), smallest worthwhile change (SWC), and minimal detectable change (MDC) were calculated. Paired t-test revealed no significant differences between test and re-test for first ($t = -0.09$, $p = 0.92$), mean of three ($t = -0.37$, $p = 0.71$), and best of three ($t = -0.02$, $p = 0.98$) trials. The ICC values showed poor relative reliability when the first trial was observed, while for the mean and best of three trials, reliability was consistently very high (excellent). The absolute reliability parameters (within-individual variation) showed large variations ranging from 5% to almost 10% and greater SEM (12.63 cm) for first trial when compared to other variables. The SEM was higher than SWC for all variables when the small differences (i.e., 0.2 multiplied by between-participants SD) were considered. This test showed a high level of absolute and relative reliability and usefulness, which means that the SRB test is an excellent indicator of reaction speed in young volleyball players.

Keywords: reaction speed, reliability, young volleyball players

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INTRODUCTION

Reaction speed is a player's ability to make decisions and act. It can be divided into two components. First is "*reaction time*" which is the time between exposure to a stimulus (acoustic, visual, tactile, kinesthetic) and the first muscular reaction. The second component is "*movement time"* that can be defined as a duration of a move [1,2]. Volleyball players train in a dynamic environment where they require in a short time great adaptation capacity and need to have an adequate level of cognitive skill, motor, and coordination capacities. For example, middle blockers task is to identify opponent's intention where the reaction speed comes to the high manifestation [3,4].

As one of five basic components of coordination [5], reaction speed has a positive impact on volleyball performance [5,6]. Modern volleyball has dramatically changed over the last decades. Coordination abilities become more important for a high-performance level because of skill complexity [7], and the players have limited time to react and respond [1,8]. In volleyball, according to Mroczek [1], reaction speed is ranked in the first place among all coordination abilities. A high level of reaction speed withdraws a better ability to read the game and anticipate what will happen before the opponent makes the action [6]. Skilled players are better in information extraction that is globally distributed across the body, rather than relying on a single isolated or local information cue or source [9]. Generally speaking, volleyball is a specific and complex game because of its short possession of a ball by one player, monitoring the ball's direction, and tracking the position of teammates and opponents on the court [10].

In several studies, reaction speed has been assessed with computerized tests, such as the Motor reaction test, Simple reaction time test, and Choice reaction time test [6,11–13]. Although they are reliable, they cannot replace sports activity situations [14]. Computerized tests put an accent on reaction time separating movement time component, which is not typical for sport-specific movements that require athletes to initiate large muscle groups [15,16]. Moreover, computerized tests require individuals to activate only small muscles without whole-body movement. Most reactive actions in sports are multi-joint movements that require the control of large muscles. Therefore, the precise response time of various simple and complex sport-specific actions can be achieved only by activating large muscle groups [15,17,18]. Additionally, large muscle groups activation can conceal deficiency in the components of reaction speed, such as the fact that the upper limbs are significantly faster than the lower limbs [19]. However, when recruiting large muscle groups, there is a possibility of unwanted inter-trial variability in movement. When a person repeats the same motor task over time, the movement produced is never the same. Inter-trial variability is greater in young children, and during motor development, movements gradually become more consistent. Consistent movement assumes that movement noise (unpredictable fluctuations) is kept under control [20]. Unwanted inter-trial variability can produce measurement error which inflates a participant's true score. Moreover, the participant's arousal, alertness, or motivation can account for greater trial-to-trial variation [21]. To adopt the optimal testing procedure, analysis of first, mean of three, or best of three trials can provide better insights on the reliability of reaction speed testing in athletes. Moreover, the testing procedure may differ between fully developed and youth athletes due to an immature nervous system and ability to focus on the task [22].

Therefore, this study aimed to determine test-retest reliability and usefulness of the Stopping the rolling ball test (SRB) in young female volleyball players. This previously constructed test for reaction speed ability assessment was chosen because of specific "reach and touch" motor tasks where players have constant anticipation in a dynamic environment [3,15]. Additionally, to determine the highest stability of SRB scores in young players, the first trial, mean of three trials, and the best of three trials reliability analysis was performed.

MATERIAL AND METHODS

Participants

A total of 28 female youth volleyball players (age 11.23±0.67 yrs, training experience 2.03±0.69 yrs) were included in the research from three volleyball clubs in Bosnia and Herzegovina. At the moment of testing, their training regime was two to three times per week. Parents of all participants were informed of the risks and benefits of the research and testing procedures. Written consent was received before participating in the study. They were also told that any of the participants (their child) could quit testing any time without any penalty. The inclusion criteria for participation in this research included: (1) at least one year of training experience, (2) being healthy (i.e., absence of cardiovascular disease, no history of chronic disease, illness, surgeries, hospitalizations, and musculoskeletal or joint injuries) and (3) having a valid sport medical certification. The investigation was conducted in accordance with the 1975 Declaration of Helsinki ethical principles for scientific investigations and approved by the Ethical Committee of the University of Split (number: 2181-205-02-05-20-025; 3 December 2020).

Experimental procedure

The test was performed on an indoor gym with a mean ambient temperature of ~25°C and ~65% relative humidity. To assess test-retest reliability, participants performed a test on two sessions with the 14-day interval in between [23]. All the participants had one initial attempt and three trials. A standard warm-up was conducted before the testing, which included 4 minutes of jogging and 6 minutes of head, shoulders, hips, and knee mobility exercises, all demonstrated by the measurer. Procedures were conducted by sport and exercise scientists, members of the Faculty of Kinesiology, University of Split. The principal investigator conducted both testing sessions (test-retest) in the same conditions, who initially demonstrated the SRB test, explained the procedures and monitored all trials. The second investigator recorded performance scores.

Stopping the rolling ball

Reaction speed was assessed by applying the Stopping the rolling ball test (SRB)[24]. The test was modified because every school in Bosnia and Herzegovina has a different standard for the size and quantity of benches. Participants stood behind two benches length 220 cm (5 cm distance between them), 150 cm from the lower edge of the benches with his back turned away in the opposite direction (cannot see the ball). Benches were leaned at the height of 120 cm so the volleyball ball could roll. The meter was attached to the surface of the bench. The principal investigator held a ball at the top of the benches (meter), and after the audio signal, he released the ball so that it rolls down between the benches. Participants' task was to turn around, run to the ball and stop the ball with both hands as fast as possible. The travelled distance of the ball was recorded after each attempt.

Statistical analysis

All data were analyzed with Statistica for Windows (Statsoft, version 14) and GraphPad Prism 9 (GraphPad Software, Inc.) and are presented as mean and standard deviation. The normality of the sample and homogeneity of variances was tested using Shapiro-'Wilk's test and 'Levene's test. The following important components of reliability were calculated: (a) systematic bias, (b) within-individual variation, and (c) retest correlation (i.e. "relative" "measure of random error). Paired t-test was used to determine systematic bias/difference between two testing occasions (test/retest). Additionally, effect size was calculated using Cohen's d [25], with values of <0.2, >0.2 and <0.6, >0.6 and <1.2, >1.2 and <2.0, and ≥2.0 considered as trivial, small, medium, large, and very large effects, respectively [26]. Standard error of measurement (SEM) and standard error of measurement

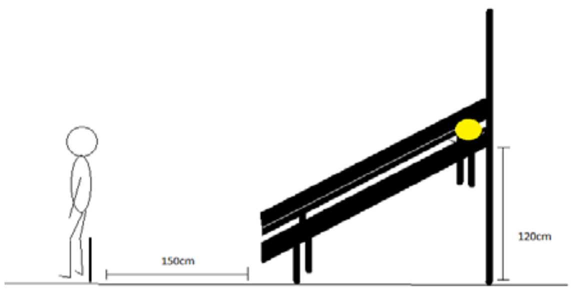

Figure 1. Visual representation of the SRB test

expressed as coefficient of variation (CV%) were calculated to determine within-individual variation, and the 95% confidence interval was also presented. The retest correlation was assessed with a two-way mixed model intraclass correlation coefficient (ICC) according to Koo and Li [27]. ICCs values of ≤0.4, >0.4 and <0.59, >0.6 and <0.74, and >0.75 are considered as poor, fair, good and excellent respectively [28]. The smallest worthwhile change (SWC) was also calculated for various effect sizes (0.2, 0.6, and 1.2 multiplied by the between-'participants' standard deviation, based on the 'Cohen's effect size principle, for small, medium, and large effect sizes, respectively). The usefulness of the test was determined by comparing the SWC score with the SEM [29]. If the SEM is lower than the SWC, then the test is rated as "good." If the SEM is higher than the SWC, then the test is rated as "marginal." If the SEM is about the same as the SWC, then the test may be useful or "satisfactory" [30]. Additionally, the minimal detectable change (MDC) was also calculated (SEM x 1.96 $\sqrt{2}$) for the interpretation of changes 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 and to complement the SEM [31]. Finally, repeated-measures ANOVA with effect sizes presented as partial eta-squared (η^2) was used to test statistical differences between the individual trials of each testing day (test, retest). The significance level was set at $p < 0.05$.

RESULTS

All twenty-eight participants successfully completed SRB three trials without any complications. Figure 2 represents individual responses during the test and retest of the SRB. The analysis of variance revealed that there were no significant differences between trials on test ($F_{2,54}$= 0.48, p = 0.62, η^2 = 0.02) and retest ($F_{2,54}$= 0.7, p = 0.5, η^2 = 0.03).

Performance responses during the test and retest of the SRB are presented in table 1. Paired t-test revealed no significant differences in participant's performance outcomes (no systematic bias) between test and retest for SRB_{trial1} (t = -0.09, p = 0.92), SRB_{mean} (t = -0.37, p = 0.71), and SRB_{best} (t = -0.02, p = 0.98). High individual consistency in results between two testing occasions is observed for a mean of three trials and the best of three trials, while low consistency is found in the first trial of the SRB test (figures 3, 4, and 5).

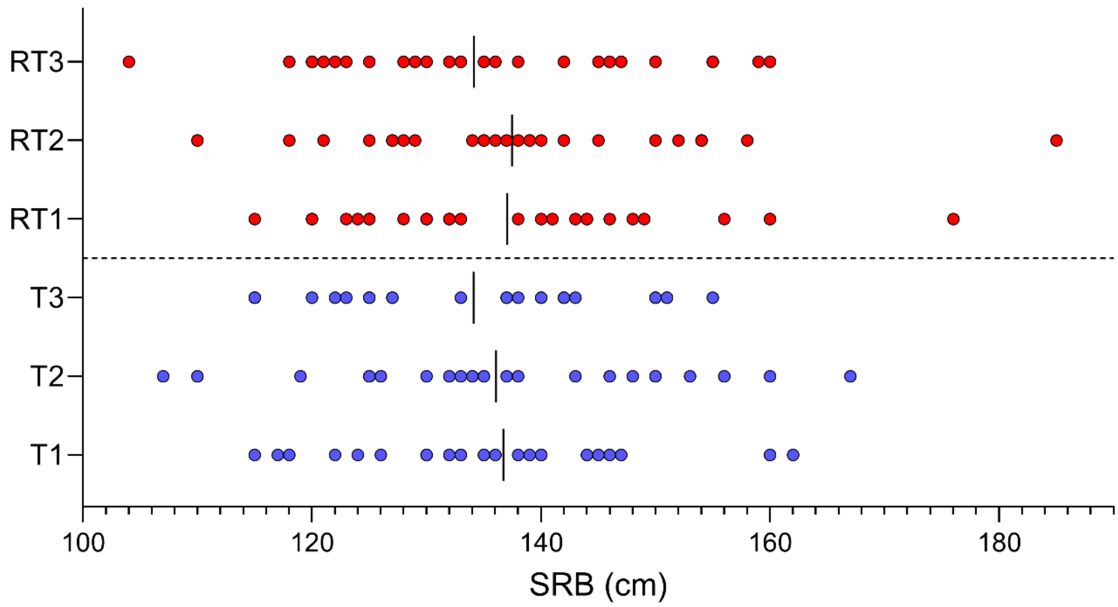

Figure 2. Individual performances during test and retest of the SRB, T – test; RT – retest.

Table 1. Performance responses during test and re-test of the SRB.

variable	Test	Retest	ES(95%CI)
SRB_{trial1}(cm)	136.71(12.35)	137.03(14.4)	-0.02(-0.55 – 0.5)
SRB_{mean}(cm)	135.63(10.62)	136.22(11.46)	-0.05(-0.58 – 0.47)
SRB_{best}(cm)	126.5(11.64)	126.53(11.99)	0.00(-0.53 – 0.52)

Legend: values are presented as mean and standard deviation; ES(95%CI) = effect size and 95% confidence interval; SRB_{trial1} = first trial; SRB_{mean} = mean of three trials; SRB_{best} = best of three trials

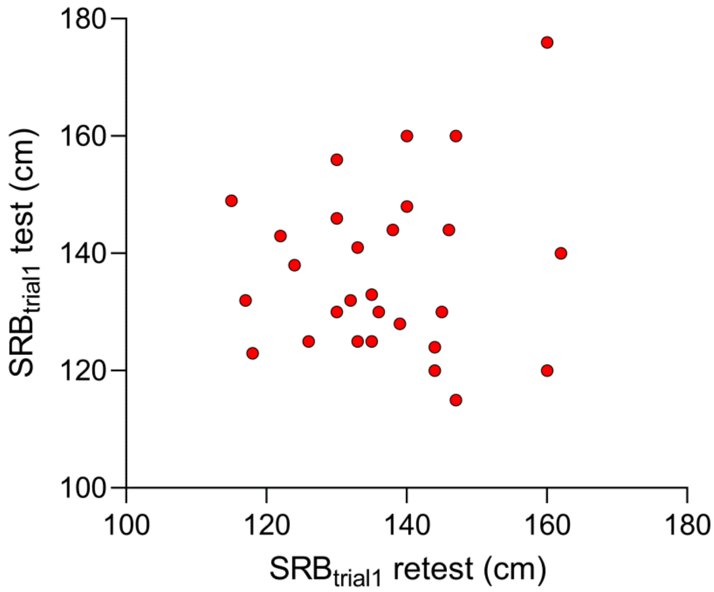

Figure 3. Scatterplot of the first trial obtained for the SRB at the test and retest.

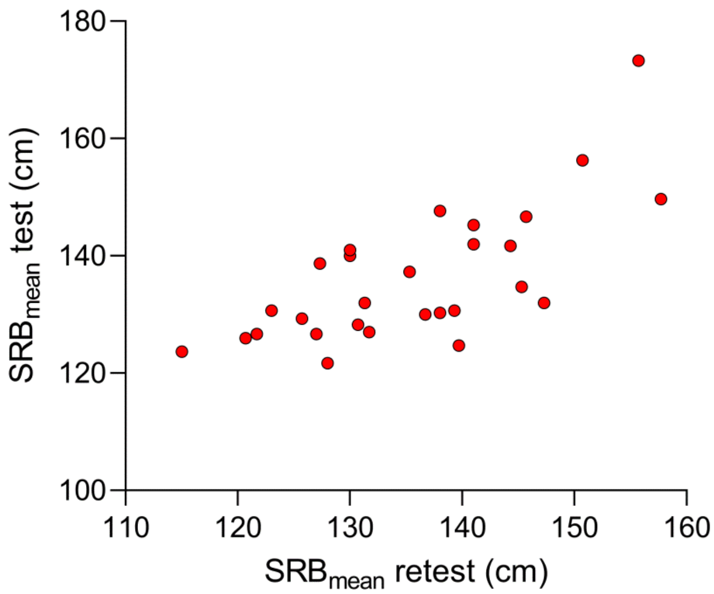

Figure 4. Scatterplot of the mean of three trials obtained for the SRB at the test and retest.

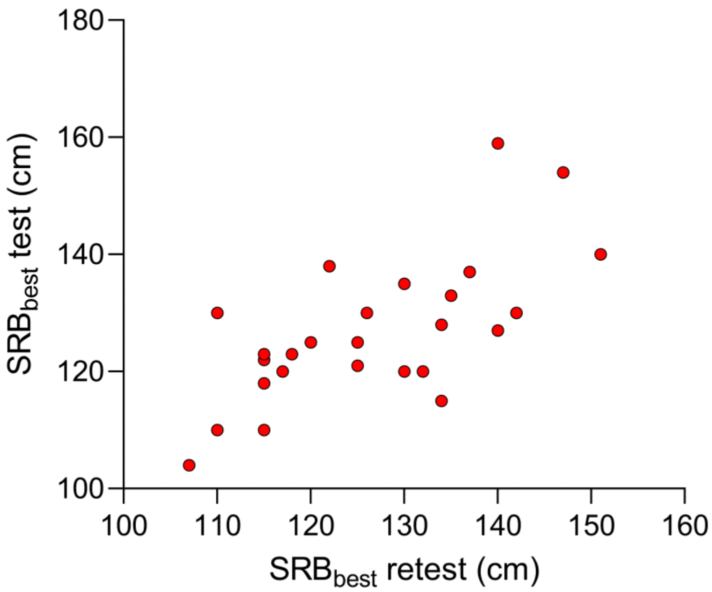

Figure 5. Scatterplot of the best of three trials obtained for the SRB at the test and retest.

Table 2. Measures of reliability and usefulness of performance variables of the SRB test

variable	ICC(95%CI)	SEM(95%CI)	SWC(0.2, 0.6 and 1.2)	CV(%)	MDC
SRB_{trial1}(cm)	0.21(-0.71 – 0.64)	12.62(10.35 – 16.32)	0.91, 2.73, 5.46	9.67	34.98
SRB_{mean}(cm)	0.84(0.64 – 0.92)	5.92(4.68 – 8.06)	1.87, 5.6, 11.2	4.37	16.41
SRB_{best}(cm)	0.81(0.59 – 0.91)	6.71(5.31 – 9.14)	1.95, 5.84, 11.68	5.33	18.6

Legend: ICC(95%CI) = intraclass correlation coefficient and 95% confidence interval; SEM = standard error of measurement and 95% confidence interval; SWC = smallest worthwhile change; CV (%) = standard error of measurement expressed as cofficient of variation; MDC = minimal detectable change; SRB_{trial1} = first trial; SRB_{mean} = mean of three trials; SRB_{best} = best of three trials

Measures of reliability and usefulness of performance responses to the SRB test are presented in table 2. The ICC values showed poor relative reliability when the first trial was observed, while for the mean of three trials and the best of three, reliability between test occasions was consistently very high (excellent). The absolute reliability parameters (within-individual variation) showed large variations ranging from 5% to almost 10% and greater SEM (12.63 cm) for SRB_{trial1} when compared to other variables. The SEM was higher than SWC for all variables when the small differences (i.e., 0.2 multiplied by between-participants SD) were considered.

DISCUSSION

This study is the first investigation to evaluate the reliability and usefulness of SRB among young volleyball players. The SRB test scores on two testing occasions showed excellent absolute and relative reliability of SRB_{mean} and SRB_{best}. This implicates that both approaches are equally useful when assessing reaction speed ability in young volleyball players. Although SRB_{mean} and SRB_{best} showed excellent reliability (ICC=0.81 to 0.84), these results could be higher if participants were 13 years old and above when the complex motor reaction reaches its maximum [24,32]. However, ICC can be affected by the heterogeneity of the sample, and therefore, it is recommended to use SEM and CV as additional measures of absolute reliability [33].

The SEM is considered to be a parameter for the amount of measurement error present in a test [34]. Furthermore, SEM represents precision or the trial-to-trial noise of the test. The SEM values in this investigation are considered as small (below 10%), which suggests that the SRB test didn't differ in two testing occasions [35]. Furthermore, SEM value is useful to determine the minimal detectable change (true changes in performance) that athletes must show between two testing occasions to ensure that the observed change is real not just measurement error. This research revealed that the MDC was from 12 to 25% [36]. Despite the relative reliability being acceptable, the usefulness of the test must be taken into account. As shown above, the difference between SEM and $SWC_{(0.2)}$, which we can define as the ability to detect a meaningful change in tests, was large. The $SWC_{(0.6)}$ was satisfactory, and $SWC_{(1.2)}$ was higher than SEM, indicating "good" usefulness. In other words, the test can be utilized to detect changes that exceed 0.6 to 1.2 times the test standard deviation [30]. Within-individual variation values (lower than 6%) may be interpreted as good absolute reliability, meaning that typical variation from test to test will be around 6 cm for SRB_{mean} and SRB_{best}. A similar coefficient of variation was found in reproducibility studies on the assessment of sport-specific reaction time [16,37]. Good reliability and usefulness indicate that the SRB test is a valid tool for assessment of the reaction speed ability in young volleyball players. The SRB_{trial1} showed poor reliability (low and non-significant ICC) and low usefulness (rated as "marginal"; SWC [0.2, 0.6, and 1.2] considerably smaller than SEM). The reliability of a measure based on a single item can be compromised by a lack of variability across all participants [21]. This is important because If reproducibility between the first trial is high, practicians can consider saving time by having only one trial/attempt, which can be wrong. The poorest SRB scores occurred in the first trial, which can be attributed to the fact that young players may learn tasks over trials. Possible learning effects can exhibit in young athletes while performing complex tasks [38]. Moreover, younger participants might exhibit greater learning effects due to the novelty of the task and motor development processes [22,39].

The SRB uses distance instead of time as a measurement of reaction speed. A similar concept to record reaction was applied in RT_{clin} test [40]. The authors used a thin, rigid cylinder to which a weighted disk is attached. The cylinder is released by the investigator and then caught as quickly as possible by the athlete. The distance of the falls before being grabbed by the hand is measured. However, researchers were able to convert the distance into the reaction time by using the formula for a free body falling under the influence of gravity. The same principle was not possible in the SRB test due to the angle of the benches and the distance between them.

Our results should be considered in light of few limitations. First, the reliability in physical performance is crucial when establishing whether a new test is valid and applicable, and construction of the new sport-specific tests is not an easy task [41]. Instead of constructing a new test, this investigation attempt to assess reproducibility and applicability of the previously constructed SRB test by determining absolute and relative reliability, which is a prerequisite to establishing the validity of a new test. Although this research did not deal with the validity of the SRB test, future research should conduct test validation analysis and compare obtained findings with previous well-established tests that assess reaction time in young athletes. Second, The SRB test does not simulate game-specific movements of opponents and ball, which can affect the pattern recognition in the stimulus-identification stage differently than simple reaction stimuli like audio signals [42]. Third, the sample size is small, and it is unknown whether a larger number of participants would produce the same or similar results. Moreover, the sample included only female participants. Although girls predominate at this age, future research should include boys to verify the generalizability of these findings. Forth, as this is the first investigation dealing with the reliability of the SRB test, comparison with the previous findings was not applicable.

CONCLUSION

In conclusion, the present investigation showed that the SRB test has good levels of reliability and usefulness in young volleyball athletes. Reaction speed impacts volleyball where the game is dynamic, and players must react quickly to the changing situation ("reading" the game), which requires a fast multi-joint movement response. Consequently, this research demonstrates that the SRB test is an excellent indicator of reaction speed in young volleyball players. A minimum of three test trials is recommended for future investigations due to the learning effect and possible lack of variability when only one trial is analyzed. Additionally, the discriminative and construct validity of the SRB test should be evaluated in future investigations. It would be interesting to establish how well the SRB test can differentiate athletes of different quality levels and the relationship with other tests assessing reaction speed.

DECLARATION OF COMPETING INTEREST

The authors have no conflicts of interest to declare.

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