METRIC CHARACTERISTICS OF THE MODIFIED STEP-HOP TEST FOR ASSESSING SPECIFIC AGILITY IN YOUNG FEMALE VOLLEYBALL PLAYERS

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Abstract
The aim of this study was to determine whether modification of the Step-hop test for assessing specific agility in volleyball would significantly shorten the performance time and improve homogeneity, i.e., reduce the differences between certain test items. The subject sample included 53 Croatian female volleyball players whose mean chronological age was 14.09±0.83 years, mean body height was 173.66±6.07 cm, and mean body mass was 61.12±9.40 kg. It was determined that the Modified Step-hop test had better reliability (CA=0.96 and CV=0.10) as compared to the Step-hop test (CA=0.93; CV=0.37). By simplifying performance, homogeneity of the test was improved (Step-hop F-test = 40.78; Modified Step-hop F-test = 10.76), and mean test performance time was shortened (Step-hop Mean = 10.75 sec; Modified Step-hop Mean = 9.78 sec). Even though correlation between the applied tests was significant (r=0.71), 50% of common explained variance points to somewhat different manifestations of agility required for performance of these tests. It can be assumed that the Step-hop test, due to unusual way of movement direction change, could also be applied to assess specific coordination, whereas the Modified Step-hop test has better metric characteristics for assessing specific agility in young female volleyball players.

Key words: volleyball, agility, test modification, reliability, sensitivity.

Introduction
Volleyball is a very dynamic sports game characterized by vertical jumps, forceful hits of the ball, but also sudden starts and stops, as well as frequent movement direction changes (Grgantov et al., 2006). Due to small dimensions of the volleyball court (18x9 meters), all these movements take place in small distances, thus volleyball players cross only 11 meters during one rally (Mroczek et al., 2014). Even though the reactive component of agility, which has been emphasized by numerous authors (Sheppard & Young, 2006; Oliver & Meyers, 2009, Horička et al., 2014; Sekulić et al., 2014) is very important, training aimed at developing this component in young athletes (reactive agility training – RAT) during pre-puberty and at the beginning of puberty should represent only 15-30% of overall agility training (Lloyd et al., 2013). Much greater percentage of exercises for development of agility at this age should be aimed at development of motor components of agility, i.e., development of fundamental movement skills (FMS) and change of direction speed (CODS). Such agility training should result in proper performance technique which then reduces the risk of injury, especially of cruciate ligaments in the knee during cutting movements. Besier et al. (2001) established that ligament loading at the knee joint increases during unanticipated cutting maneuvers which are specific to reactive agility exercises. The risk of injury of anterior cruciate ligaments is significantly higher in women (Ford et al., 2005). The importance of RAT increases during puberty, especially in the period following puberty when it should constitute up to 60% of agility training (Lloyd et al., 2013). Apart from the aspect of acquisition of proper movement technique and prevention of injury, training and testing the motor component of agility during pre-puberty and puberty is also important because this agility component has proven to be a good predictor of competitive efficiency in these age groups in volleyball (Grgantov et al., 2006; Katić et al., 2006; Gabbett, & Georgieff, 2007; Milić et al., 2012; Milić et al., 2013). However, in all these studies agility was assessed by tests whose performance is not specific for some volleyball players’ movements which take place in small distances under 3 meters. Lloyd & Oliver (2012) point out that increased agility training and testing by sport-specific exercises and tests should begin at pre-puberty and puberty. Đurković et al. (2008) constructed an agility test (Step-hop test) which, to a certain extent, takes into account the specificities of volleyball players’ movements during performance of different volleyball elements, e.g., serve reception, field defense, etc. The authors validated the test on a relatively small sample of junior and senior volleyball players and the analysis did not include inter-positional and intra-positional differences. Grgantov et al. (2016) thus analyzed the metric characteristics of the Step-hop test on a larger sample of young female volleyball players. In doing so, they also analyzed inter-positional and intra-positional differences in test performance. They determined good reliability and sensitivity of the test. There were no significant inter-positional differences found, and the test significantly differentiated more successful from less successful volleyball players only at the passer-hitter position. However, during the measurement, it was determined that a certain number of players had problems with test performance, so the test had to be stopped and repeated. They came to the conclusion that this was caused by the unusual way...
of changing the movement direction during diagonal movements from the lower left to the upper right square and from the lower right to the upper left square (marked by the arrow connecting the squares 1 and 2 and the arrow connecting the squares 3 and 4 in Figure 1). Therefore, the authors suggested that performance of the Step-hop test should be modified so that every change of movement direction is initiated by the foot opposite from that which was last put on the floor in the previous movement. Jeffreys (2006), pointed out that agility was a neuromuscular skill, that athletes are not always employing maximum speed in all movements, and that control of movement was most important in the initial stages of development. All of this indicates that agility depends upon appropriate movement control. It can be assumed that young female volleyball players could not fully manifest their agility during performance of the Step-hop test. Thus, the aim of this study was to determine whether, by modifying the Step-hop test, the time of performance would be significantly shortened and homogeneity improved, i.e., if the differences between the items of the three measurements Step-hop test would be reduced.

Methods

The subject sample of this study included 53 Croatian female volleyball players, members of volleyball clubs from the Dalmatia region competing in the South youth league, whose mean chronological age was 14.09±0.83 years, mean body height was 173.66±6.07 cm and body mass was 61.12±9.40 kg. The inclusion criterion was determined by chronological age defined by the Croatian Volleyball Federation for the U-15 age group, training experience (minimum of 2 years of active volleyball training) and by competitive engagement in their club’s U-15 team. During measurement all participants were physically healthy, without noticeable psychophysical aberrations. All subjects had ID cards provided by the Croatian Volleyball Federation and verified by an authorized sports physician. Informed consent from parents was obtained according to the Declaration of Helsinski. Variable sample included 2 motor agility tests (Step-hop test and Modified Step-hop test).

Step-hop test

The test is performed on a flat and non-slippery surface marked with a 3x3-m square which has 30×30-cm squares marked in its corners. A subject stands with both feet face forward to the right side line of the square. Subject’s feet are parallel. Her left foot is in the upper left square (0). When a subject is given the mark, she performs the first step with her right foot sideways, and then a hop with both feet, making sure that her right foot is touching the sides of the lower left square (1) when she hops. Then she steps with her right foot diagonally forward to the right and hops in a way that her right foot touches the upper right square (2). The next step sideways is performed with the left foot, followed by a hop, so that a part of the left foot touches the back right square (3). This is followed by a left foot step diagonally forward to the left and a hop. After performing the last hop, a subject stands in the same position in which she started the test (4). The goal of the test is to perform 2 predefined movement cycles in the shortest time possible, measured in seconds. The test is performed 3 times with a pause sufficient for recovery (Figure 1).

Modified step-hop test

The test is performed in a way similar to the previously described Step-hop test, except that after hopping into a square, the movement towards the next square always starts with the opposite foot from that which was the last to touch the surface in the previous movement. A subject stands with both feet face forward to the right side line of the square. Subject’s feet are parallel. Her left foot is in the upper left square (0). When a subject is given the mark, she performs the first step with her right foot sideways, and then a hop with both feet, making sure that her right foot is touching the sides of the lower left square (1) when she hops. Then she steps with her left foot diagonally forward to the right and hops in a way that her left foot touches the upper right square (2). The next step sideways is performed with the right foot, followed by a hop, so that a part of the right foot touches the back right square (3). This is followed by a left foot step diagonally forward to the left and a hop. After performing the last hop, a subject stands in the same position in which she started the test (4).

The goal of the test is to perform 2 predefined movement cycles in the shortest time possible, measured in seconds. The test is performed 3 times with a pause sufficient for recovery. All tests were conducted in the evening time (between 7 and 9 pm) to avoid any influence of circadian variation (Ammar et al., 2015). Before the testing, participants performed a standardized 15-minute warm-up. Participants started the warm-up with 3 minutes of jogging, followed by 7 minutes of dynamic stretching exercises (Chaouachi et al., 2015), and then performed specific agility drills for 5 minutes. Two days before the testing, volleyball players did not have training with a significant load so fatigue did not affect the testing results (Gheller et al., 2015). The participants were divided into two groups, by random selection. The first group first performed the Step-hop test three times, and then repeated the Modified Step-hop test three times.
The second group performed the tests in reversed order. Each group within a club included between 6 and 8 subjects. Participants performed each repetition one after another, which allowed them optimal recovery time before the following repetition. This helped to avoid possible effect of fatigue or insufficient warm-up on the results of performance of the following test repetition. All measurements were taken by a sports scientist. The data analysis included calculation of metric characteristics of motor tests: reliability (by calculating the Cronbach’s alpha coefficient, CA, and the coefficient of variability, CV), homogeneity (by using univariate analysis of variance – ANOVA) and sensitivity (by calculating the coefficients of asymmetry and peakedness of result distribution, SKEW and KURT and MaxD value for determining significant deviation from normal distribution of variables by Kolmogorov-Smirnov test - KS test). Descriptive indicators of variables included calculation of arithmetic mean (AM), median (M), minimum result (Min), maximum result (Max), and standard deviation (SD). Pearson's coefficient of correlation was calculated to determine the correlation between results obtained by performing two different variants of the Step-hop test. The dependent sample t-test was used to analyze the significance of differences in results of the applied tests. Data were analyzed by the Statistica Ver.12.0 software.

Results and discussion

Reliability of the Step-hop and Modified Step-hop test was determined by the Cronbach’s Alpha (CA), as coefficient of internal consistency between the measured items. Inter-item variability was determined by coefficient of variation (CV). Homogeneity of items of the applied tests was analyzed by F test (Table 1).

<table>
<thead>
<tr>
<th>Motor tests</th>
<th>CA</th>
<th>CV</th>
<th>AM±S</th>
<th>AM±SD</th>
<th>AM±SD</th>
<th>F-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step hop test (s)</td>
<td>0.93</td>
<td>0.37</td>
<td>11.47±1.30</td>
<td>10.83±1.23</td>
<td>10.64±1.18</td>
<td>40.78*</td>
</tr>
<tr>
<td>Mod. Step hop test (s)</td>
<td>0.96</td>
<td>0.10</td>
<td>10.22±0.80</td>
<td>9.98±0.84</td>
<td>9.82±0.80</td>
<td>17.60*</td>
</tr>
</tbody>
</table>

Legend: CA - Cronbach’s alpha. CV - coefficient of variation of measured items, AM1 - arithmetic mean of the first measuring, AM2 - arithmetic mean of the second measuring, AM3 - arithmetic mean of the third measuring, SD1 - standard deviation of the first measuring, SD2 - standard deviation of the second measuring, SD3 - standard deviation of the third measuring, F-test - test value at testing significance of differences between AM of the first, the second and the third measuring, * - significance of differences at the level of p≤0.05.

By analyzing the Cronbach’s alpha coefficient and coefficient of variation, it can be noticed that the Modified Step-hop test has better reliability in comparison to the Step-hop test. Furthermore, it is noticeable that in the first repetition young volleyball players were more than a second faster when performing the Modified Step-hop test in comparison to the Step-hop test, whereas in the second and the third repetition the difference was slightly under one second. Moreover, by simplifying performance, the differences between certain test items were also reduced, i.e., homogeneity of the test was improved. Considering that in a previous study (Grgrantov et al., 2016) it was noticed that a certain number of players failed to perform the Step-hop test properly, in this study investigators kept record of this and established that 9 players had to repeat certain items of the Step-hop test once or several times due to improper performance. All mistakes occurred during one of the 4 movement direction changes in which new movement is initiated with the opposite foot from that which ended the previous movement, instead with the same foot. None of the players had to repeat the performance of the Modified Step-hop test, which additionally confirms justifiability of the proposed changes in the way this test is performed to assess specific agility of young female volleyball players.

Analysis of distribution indicators of the Step-hop and Modified Step-hop test showed that there were no significant deviations from normal distribution, which means that both tests were suitable for further parametric statistical analysis. By analyzing the descriptive indicators presented in Table 2 it can be noticed that young female volleyball players were averagely almost a second faster when performing the modified version of the Step-test, as compared to the original test.

Statistical significance of those differences was determined by dependent sample t-test. The differences in speed of performance probably occurred during the aforementioned movement direction changes, which were previously pointed out as unusual by Grgrantov et al. (2016). In volleyball, sudden movement direction changes are frequent, e.g., during blocks, transition from block to field defense or infield defense when the opponents’ spiked ball touches the block of the defending team. In those situations, reaching the ball even a split second faster can make all the difference between unsuccessful and successful play. This is why it is important to teach young volleyball players the proper techniques of movement direction changes, and not to concentrate only on techniques of ball play.

Correlation analysis found significant correlation between the results in two variants of the Step-hop test on the tested sample. However, 50% of common explained variance points to somewhat different manifestations of agility required for performance of these tests. Considering better homogeneity and shorter performance time, the Modified Step-hop test can be recommended for testing agility in young female volleyball players. However, this does not mean that the original Step-hop test (Durković et al., 2008) should not be used in volleyball.
Due to reorganization of the usual way of movement direction change, this test could find its application in testing specific coordination of young female volleyball players. According to Kurz (2001), movement coordination, as a nervous regulation of muscular activity, is a basis for developing efficiency in movements and perfecting technique. It is an expression of the ability to localize processes of excitation to the proper motor centers and to prevent a spilling over of excitation to other centers which would result in one movement pattern interfering with another. Pion et al. (2015) point out that good coordination allows athletes to move in a controlled way over the limited playing surface. They connected the initial test results in different motor abilities with subsequent performance classifications after 5 years of training and competition on a sample of 21 young female volleyball players who were selected to train at the Flemish Top Sports Academy for Volleyball in 2008.

By retrospective analysis of test results 5 years in the past, they established that only the coordination tests were good predictors of success in senior age group, i.e., they were successful in differentiating players of sub-elite and elite level. There have been studies by other scientists (Lidor & Ziv, 2010; Katić et al., 2006) which also demonstrate that high skill levels and general motor coordination are indeed performance-related factors affecting success during female volleyball competition. From this point of view, female volleyball players who have better coordination of movements should have less difficulties when performing unusual movement direction changes over the limited playing surface which are characteristic for the Step-hop test, which also affects the time of test performance. Coordination can also be defined as speed of acquiring new motor skills. This is why, when assessing coordination, apart from time of performance of the Step-hop test, the differences in time of performance between certain test items should also be taken into consideration. Greater differences between items (more prominent learning effect) could indicate better coordination. The differences in time of performance of the Step-hop test and the Modified Step-hop test could also be taken into consideration, where smaller differences in performance time could indicate better coordination.

**Conclusion**

Modification of the Step-hop test improved its metric characteristics, which points to the necessity of its application in assessing specific agility in young female volleyball players. It can be assumed that the Step-hop test, on its own or combined with the modified variant, can be used as a test for assessing specific coordination in volleyball. In doing so, it would be necessary to construct coordination indices which would take into consideration not only the time of performance of the Step-hop test but also the differences in time of performance of certain items, as well as the differences in time of performance of the two variants of the Step-hop test. Thus, the authors recommend that in future studies the possibility of application of the Step-hop test and the Modified Step-hop test should be analyzed in this way, with the purpose of talent identification in volleyball.

**References**


METRIJSKE KARAKTERISTIKE MODIFICIRANOG STEP‐HOP TESTA ZA PROCJENU SPECIFIČNE AGILNOSTI KOD MLADIH ODBOJKASICA

Sažetak
Cilj ovog istraživanja bio je utvrditi bi li preinaka step-hop testa za procjenu specifične agilnosti u odobojci značajno skratila vrijeme izvedbe i poboljšala homogenost, odnosno, smanjila razlike između pojedinih ispitnih predmeta. Uzorak je uključivao 53 hrvatske odbojkašice čija je srednja kronološka dob bila 14,09 ± 0,83 godina, dakle tijelo visina 173,66 ± 6,07 cm i prosječna masa je 61.12 ± 9.40 kg. Utvrđeno je da je promjena step-hop testa imala bolju pouzdanost (CA = 0,96 i CV = 0,10) u odnosu na step-hop test (CA = 0,93, CV = 0,37). Promjena step-hop testa poboljšana je (korak-hop F-test = 40.78; Promjena korak-hop F-test = 10.76), dakle srednje izvedbenu vrijeme testa bilo je skraćeno (step-hop Mean = 10.75 sek, Promjena step-hop Mean = 9.78 sekundi). Iako je nezavisnost između primijenjenih testova bila značajna (r = 0.71), 50% zajedničke objašnjene varijance ukazuje na nešto različite manifestacije agilnosti potrebne za obavljanje tih testa. Može se pretpostaviti da je step-hop test, zbog neobičnog načina smjera kretanja promjena, također primjenjiv za procjenu specifične koordinacije, a promjena step-hop test ima bolje metrijske značajke za procjenu specifične agilnosti u mladih odbojkasica.

Ključne riječi: odbojka, okretnost, modifikacija testa, pouzdanost, osjetljivost.