Proceeding

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Relationship between musculoskeletal state and vertical jump ability of young basketball players

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ABSTRACT

The aim of this study was to evaluate the musculoskeletal state and jumping ability and to analyse the relationships between fundamental movement patterns and the jumping height of male junior level basketball players. Fifty four Under 18 (U-18) years basketball players were evaluated according to FMS 21 and 100 point scale and height of Squat (SJ) and Countermovement jump (CMJ). Spearman and Pearson correlations were carried out to identify whether a relationship existed between FMS scores and the height of SJ and CMJ. The moderate correlations were found between height of both jumps and FMS score (SJ, r = 0.375; CMJ, r = 0.498), whereas the sub-tests show a reliable correlation between the Deep Squat (DS) score and CMJ height (r = 0.315). A higher height of CMJ was also associated with the scores of In-line Lunge (r = 0.357) and Active SLR (r= 0.291). The basis of the findings we can conclude that improvement of the jump ability can be achieved by the enhancement of the overall musculoskeletal state, which can be identified through the composite FMS score or by "Deep squat", "In-line Lunge" and "Active SLR" sub-tests. **Keywords**: FMS score; Squat jump; Countermovement jump.

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INTRODUCTION

Based on the special movements in basketball (jumps in rebounding and jump shots, frequent change of direction of movement, acceleration) the importance of lower limbs explosive strength and power and jumping ability is evident. These abilities are primary tested with vertical jump tests (Brown and Weir, 2001). It has been revealed that Squat jump (SJ) and Countermovement jump (CMJ) are the most reliable and valid tests for the estimation of explosive power of the lower limbs (Markovic et al., 2004). Ziv and Lidor (2010) in their review, note that vertical jump values varied greatly, from 22 to 48 cm in female and from 40 to 75 cm in male basketball players and explain so large variations mostly by the differences in testing protocols and skill level of players. As an example the authors note that the addition of the hand swing during the CMJ can increase vertical jump values by approximately 10 cm. Köklü, et al. (2011) observed selection of physical fitness characteristics of Turkish professional basketball players and found, among others, that the height of the Squat jump (SJ) was 36.2 ± 5.5 cm and CMJ 38.3 ± 5.3 cm. Along with other indicators Pehar et al. (2017) has examined jumping performance of professional-level male basketball players from Bosnia and Herzegovina and found that the height of the CMJ was 45.5 ±5.6 cm on average. In both studies jump tests were performed keeping their hands on their hips. Some studies have examined jumping ability among male basketball players in different age groups. In a study conducted by Kellis et al. (1999), it was revealed that the average height of jumps in both styles (SJ and CMJ) gradually increased from 27.0 ±4.5 (SJ) and 29.9 ±3.8 (CMJ) among 13 year old male basketball players to 35.6 ±5.8 (SJ) and 39.2 ±4.9 (CMJ) respectively for 18-year-olds. The development of explosive power is mainly achieved by resistance and plyometric training or complex training, a method that combines resistance training and plyometric (Santos and Janeira, 2008). Such exercises have high intensity and impose increased demands on the musculoskeletal system. Therefore, the musculoskeletal system of athletes must be thoroughly prepared and tested in advance. Such abilities can be tested using the Functional Movement Screen (FMS™), which were designed to identify areas of limitation, asymmetry and imbalance within full body movement patterns (Cook et al., 2014a). The FMS™ consists of seven motion sub-tests, each of which is evaluated on a four-point system. The points are summarized and the final grade is set on a 21-point scale (Cook et al., 2014a; Cook et al., 2014b). Athletes with equal or lower than 14 pts FMS™ score has higher injury risk and lower performance (Kiesel et al., 2007; Chorba et al., 2010). How does the musculoskeletal state affect the height of the jump? The results of the investigation conducted by Parchmann and McBride (2011) showed that the FMS™ aggregate and individual-test scores of golfers did not have a significant relationship to the height of CMJ. In contrast to previous research, the study of Conlon (2013) with nonathletic population found a moderate correlation (r = 0.428) between composite FMS™ 21- and 100-point score and CMJ height. Based on these statements we can conclude that there is no complete clarity in the relationship between the overall musculoskeletal condition and jumping ability.

Therefore, the aim of this study was to evaluate the musculoskeletal state and jumping ability and to analyse the relationships between fundamental movement patterns and the jumping height of male junior level basketball players.

MATERIAL AND METHODS

Participants

Fifty four (54) under 18 (U-18) years old male junior basketball players (age = 16.5 +/- 1.1 (SD); height = 188.1 ± 8.5 cm; body mass = 76.6 ± 12 kg) agreed to participate in the study on a voluntary basis and signed an informed consent form. Parental consent was also obtained from participants who had not yet reached adult age. The subjects were all experienced players at a competitive level for at least 4 years. The study design was approved by the local Ethic Committee of Medical Research.

Procedure and measured parameters

The measurements took place at the end of the preparatory season in September. Before the beginning of the test, a 10 min warm-up was carried out. The data were collected and analysed by two experienced researchers.

Athlete's musculoskeletal condition was assessed by the FMS™ test battery consisting of seven sub-tests: the deep squat, hurdle step, in-line lunge, shoulder mobility, active straight leg raise, trunk stability push-up, and rotary stability tests. All attempts were video recorded with two web-cameras (frame rate 30 Hz) and analysed postpone using video analysis software Kinovea 0.8.24. Athletes were evaluated according to FMS™ 21 (Cook et al., 2014a; 2014b) and 100 point scale (Butler et al., 2012). The same investigator (experienced physiotherapist) scored all the FMS™ tests.

The jumping ability was measured using a vertical squat jump with arms on hips (SJ), starting from a stationary semi squatted position and a vertical CMJ jump with arms on hips, from a standing position with a preliminary countermovement. Subjects were asked to jump as high as they could three times, and the best of the three attempts was taken into account. Before each method of jump, some trial attempts were done by each subject to get acquainted with the process of testing. Performed jumps were recorded using two Kistler force platforms. Flight time was used to calculate the change in the height of the body's centre of gravity and the measurements were done by KistlerMARS v3.03.82 software (Sharabon, 2011).

Data analysis

Descriptive statistics (mean and standard deviation values) were performed for the FMS™ composite, individual-test scores and the height of the jumps.

One-sample Kolmogorov-Smirnov test was used to identify the presence of a normal distribution. Spearman (for FMS™ sub-tests scores) and Pearson correlations (according to normality distribution test results) were carried out to identify whether a relationship existed between FMS™ scores and the height of Squat and Countermovement Jump. All statistical analysis was computed using the IBM SPSS Statistics (version 25.0) and the level of significance for all tests was set at $p<0.05$.

RESULTS

FMS™ total and the individual scores in each of the seven tests and height of the jumps is presented in Table 1. Players had a FMS™ composite score (21 p scale) under 14 points (13.75 ±1.71) on the mean. Mainly, athletes showed a poor performance (individual score <2) on the FMS movement ("Deep squat", "In-line Lunge") and stability ("Rotary Stability") tests. The average height of the SJ was 28.9 ±5.4 (cm) and in the case of CMJ 34.4 ±6.2 (cm).

The statistically significant ($p <0.01$) moderate correlations were found between height of both jumps and FMS composite score 100 point scale (SJ, $r = 0.375$; CMJ, $r = 0.498$), whereas the sub-tests show a reliable correlation ($p <0.01$) between the "Deep squat" (DS) score and CMJ height ($r = 0.365$). A higher height of CMJ was also associated with the scores of "In-line Lunge" ($r = 0.357$) and Active SLR ($r = 0.291$).

Table 1. Descriptive statistics of FMS scores and the height of jumps

N=54	Mean ± Std. Deviation
FMS composite score 21p scale	13.75 ±1.71
Deep Squat 21	1.7 ±0.50
Hurdle Step 21	2.08 ±0.55
In-line Lunge 21	1.87 ±0.48
Active SLR 21	2 ±0.65
Rotary Stability 21	1.83 ±0.51
Pushup 21	2.28 ±0.66
Shoulder Mobility 21	2 ±0.62
FMS composite score 100p scale	54.79 ±9.14
Deep Squat 100	5.57 ±1.43
Hurdle Step 100	14.43 ±2.64
In-line Lunge 100	14.3 ±3.45
Active SLR 100	5.09 ±4.05
Rotary Stability 100	3.7 ±0.91
Pushup 100	7.21 ±4.21
Shoulder Mobility 100	4.49 ±2.51
Squat jump (cm)	28.9 ±5.4
Counter movement jump (cm)	34.4 ±6.2

Table 2. Correlation (Spearman and Pearson) between the height of jumps and FMS scores of youth basketball players

N=54	Jump height SJ	Jump height CMJ
FMS composite score 21p scale	**0.344***	**0.523****
Deep Squat 21	0.204	**0.365****
Hurdle Step 21	0.166	0.224
In-line Lunge 21	0.23	0.257
Active SLR 21	**0.323***	**0.315***
Rotary Stability 21	-0.114	-0.018
Pushup 21	0.138	0.191
Shoulder Mobility 21	-0.025	0.162
FMS composite score 100p scale	**0.375****	**0.498****
Deep Squat 100	0.152	**.315***
Hurdle Step 100	0.171	0.239
In-line Lunge 100	**0.312***	**0.357****
Active SLR 100	**0.338***	**0.291***
Rotary Stability 100	-0.108	-0.014
Pushup 100	0.138	0.191
Shoulder Mobility 100	0.008	0.126

** Correlation is significant at the 0.05 level (2-tailed). ** Correlation is significant at the 0.01 level (2-tailed).*

DISCUSSION

The aim of the present study was to evaluate the musculoskeletal state and jumping ability and to analyse the relationships between fundamental movement patterns using the FMS™ and the jumping height of competitive level male youth basketball players.

The main findings of our study, related to evaluation of the musculoskeletal state, show that the mean value of the composite score for the 21-point and 100-point scales were 13.8 ±1.7 and 54.8 ±9.1, respectively. The indicator for the 21-point scale is below the level of critical value (≤14) for participation in sports activities without increased risk of injury (Kiesel et al., 2007; Chorba, et al., 2010) and for the 100-point scale is slightly lower than mean values (57.2±1.9) of middle school aged children reported by Butler et al. (2012). Hotta et al., (2015) has revealed the importance of the "Deep squat" in conjunction with "Active SLR" scores as a more effective method than a combined score for screening the risk of injury to competing men. The current sample just showed a poor performance on the "Deep squat" 1.70 ±0.50 test which show possible restrictions of ankle dorsiflexion. The "In-line lunge" 1.87 ±0.48 and "Rotary stability" 1.83 ±0.51 tests also indicate low results. The low score of the "In-line lunge" test can be the result of inadequate hip mobility in either the stance leg or the step leg, ankle dorsiflexion, and rectus femoris flexibility (Cook et al., 2014a). Hereby it is important to highlight the poor performance of the "Rotary Stability" test measured in the current study. This test assesses multi-planar trunk stability during a combined upper and lower extremity motion. If the trunk does not have adequate stability during functional activities, needed in different sports, kinetic energy will be lost, leading to poor performance (Cook et al., 2014b). The results of several studies indicate a lack of development of these qualities in athletes (Hotta et al., 2015; Marques et al., 2017). Leetun et al. (2004) highlight the importance of proximal stabilization for lower extremity injury prevention. Findings observed in the study, conducted by Marques et al. (2017) reinforce the importance of working out this muscle group in young soccer players. The results of current study show the deficiency of multi-planar trunk stability also among young basketball players.

Jumping ability of male youth basketball players tested in this study demonstrated lower mean values of the SJ 28.9 ±5.4 (cm) and CMJ 34.4 ±6.2 (cm) than reported by Köklü et al. (2011) among Turkish first (SJ (cm) 37.8 ±5.7; CMJ (cm) 40.6 ±4.7) and second (SJ (cm) 34.7 ±5.7; CMJ (cm) 36.0 ±5) division professional basketball players. Even higher performance of CMJ (cm) 45.5 ±5.6 has been shown among professional-level male basketball players from Bosnia and Herzegovina (Pehar et al., 2017). A study presented by Schiltz et al. (2009) concerning the height of the CMJ did not reveal significant differences between groups of professional basketball players 40.5 ±5.7 (cm) and juniors 41.8 ±5.8 (cm). Higher jump heights of SJ 32.2 ±3.4 (cm) and CMJ 35.4 ±3.8 (cm) were indicated also among 16 year old athletes by Kellis et al. (1999) and height of CMJ 38.6 ± 7.0 (cm) among U-18 year old players, found by Nikolaidis et al. (2015).

The current study examined the relationships between FMS™ total and the individual scores and the jumping height of male junior level basketball players. A Pearson's correlation revealed a reliable ($p < 0.01$) moderate relationship between FMS™ composite score 100 point scale and height of both jumps (SJ, $r = 0.375$; CMJ, $r = 0.498$). This result confirms the previously identified relationship in the study, conducted by Conlon (2013). A Spearman correlation show moderate relationship between the height of CMJ and "Deep squat" (DS) score 100p scale ($r = 0.365$). A higher height of CMJ was also associated with the scores of "In-line Lunge" ($r = 0.357$) and "Active SLR" ($r = 0.291$). In conjunction with these associations, it should be noted that just in these sub-tests the athletes showed the lowest scores and the low results of those tests indicate the shorter Achilles tendons and tighter hamstrings (Cook et al., 2014a; 2014b). During the jump action those problems don't allow to achieve proper squatted jump position with optimal upper body incline (Bobbert and van Ingen Schenau, 1988). Too forward inclined compensatory trunk position during the squatting at the start of concentric phase of jump cause higher co-contraction of knee extensors and flexors (Lee et al., 2016), that may compromise the power production by bi-articular leg muscles (Jacobs et al., 1996). Also the positive relationship between FMS score and jump ability can be linked with core muscles state, because earlier studies have shown positive effects of trunk stability training to vertical jump performance (Butcher et al., 2007; Dupeyron et al., 2013). At the same time our study did not find a direct relationship between jump performance and sub-test of “Rotary Stability” and “Pushup” that are the main indicators of core muscles state in FMS test battery (Cook et al., 2014a; 2014b), but those tests are performed in horizontal positions differently from jumping where the upper body is more vertical.

Summarizing current results, we can notice, that athletes with low FMS test scores do not have only higher injury risk (Kiesel, et al. 2007; Chorba, et al. 2010), but may also compromise their lower limb power production. From the battery of sub-tests the “Deep squat“ combined with “Active SLR“, and “Rotary stability“ effectively discriminates increased risk of injuries (Hotta et al., 2015) and additionally with “In-line Lunge“ sub-tests this combination can be also informative in the view of jump performance.

CONCLUSIONS

The basis of the findings we can conclude that improvement of the jump ability can be achieved by the enhancement of the overall musculoskeletal state, which can be identified through the composite FMS score or by “Deep squat“, “In-line Lunge“ and “Active SLR“ sub-tests.

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