THE IMPACT OF SQUAT DEPTH ON THE VERTICAL JUPM STRUCTURE IN FEMALE VOLLEYBALL PLAYERS

SUMMARY

Volleyball is a complex and demanding sport in which players' success is achieved through daily, hours-long training, and multiple repetitions of different, more or less complex, variants of offensive and defensive plays. Volleyball requires a tremendous amount of work from players, not only in terms of their motor skills, but also mental performance.

Volleyball players employ different ways of moving around the court during the game, enabling effective contact with the ball. In addition to volleyball - specific movements such as digs or dives, the players also make use of the basic forms of locomotion such as walking and running. A particularly important volleyball-specific locomotion activity is jumping, e.g. during blocking, attacking, setting, or serving. Unlike running or walking, jumping is an acyclic movement comprising four phases: approach, take-off, flight, and landing. The main phase of each jump is the take-off, during which the main goal of the activity is fulfilled, i.e. giving the body the speed (momentum) required for its displacement (motion).

Various types of jump tests are used in sport to assess athletes' power of lower limbs and the trunk, i.e. the level of their strength-speed preparation. One of the most common jump tests is the standing countermovement jump (CMJ) test [Fukashimo & Komi, 1987; Aragon-Vargas & Gross, 1997 a, b; Riggs & Sheppard, 2009; Król & Mynarski, 2010; Litkowycz et al., 2010]. CMJ variants include the squat jump (SJ) and the drop/depth jump (DJ). To increase the impact of the jump, the movements of body parts during a vertical jump test must be quick and well-coordinated in order to achieve a successfully high jump. Increasing jump height is an essential part of improving movement efficiency in many sports, including volleyball.

The vertical jump test itself is not simply a "sheer" measurement of an individual's level of strength-speed ability only, since it also depends on the way it is performed, i.e. on movement technique [Hudson, 1986; Bobbert et al., 1987; Kollias et al., 2004]. The performance of the vertical jump is determined by the so-called stretch-shortening cycle (SSC), i.e. the combined effects of eccentric and concentric articular contractions of the lower limbs and the trunk, and it also depends on whether the upper limbs are in swing during the take-off phase [Bosco & Komi, 1979; Lees et al., 2004a; De Villarreal et al., 2009].

Another, equally important, determinant of vertical jump performance is the appropriate mental attitude of the individual taking the test. Motivation constitutes a significant component

of a broadly understood psychological preparation, which, among other things, includes a fully planned process of strengthening the right motivation of individuals to become involved in training activities and sports competition. Thus, in the case of a simple movement, such as a vertical jump, motivation - in addition to strength-speed preparation and movement technique - exerts the decisive influence on its outcome, i.e. reaching the maximum jump height in the flight phase. This can be confirmed by the results of earlier research of the supervisor of this dissertation [Król, 2001a and 2016]. Studies of the technique of sports activities show that the movement structure is related to an athlete's motivation to accomplish a given task set for him/her. This dissertation, in some of its parts, discusses the motivational aspect of achieving a better CMJ test performance.

The main aim of the study is to assess the effect of lower limb squat depth on the structure of vertical jump motion. The other aim is to determine the "range of motion" of squat in different types of vertical jumps performed by female volleyball players at the same level of strength-speed preparation.

Results of jump tests of 15 young female volleyball players (aged 15.6 ÷ 18.4 years, body height 181.3 ± 9.6 cm, body mass 68.5 ± 8.7 kg), students of the Sports Championship School in Sosnowiec, were used in the study. The volleyball players prepared for the tests training in as similar conditions as possible. After the warm-up the players performed the following types of counter movement vertical jumps:

- counter movement jump with a squat, with no arm-swing (CMJa),
- counter movement jump with a deep squat (GCMJ),
- repeated counter movement jump with a squat (CMJb),
- counter movement jump with a shallow squat (PCMJ),
- depth jump with no arm-swing (DJ),
- special counter movement jump on cue "jump to reach the crossbar with your head" (special CMJ – SCMJ),
- counter movement jump with an arm-swing (WCMJ)

Using the SMART-E measuring system (BTS, Italy) multi-modular recordings of the players' movements were made. The system includes six infrared cameras with a frequency of 120 Hz, synchronized with a wireless Pocket EMG module for measuring muscle bioelectrical activity, and a force platform (type 9182C, Kistler, Switzerland).

A set of 20 passive markers permitting the calculation of a player's selected parameters was used. 3D modelling and calculations of kinematic parameters were performed with the BTS SMART Analyzer software.

The electromyographic signals were monitored with the aid of 1-cm^2 disposable silver/silver chloride surface electrodes. Two electrodes were placed 1 cm apart, parallel to the fibers on the belly of seven muscles: tibialis anterior (TA), medial head of the gastrocnemius (G_{med}), rectus femoris (RF), long head of the biceps femoris (BF), rectus abdominis (RA), gluteus maximus (G_{maks}), and lumbar erector spinae (ES), in accordance with the European Recommendations for Surface Electromyography – SENIAM [Hermens et al., 1999]. The EMG signals were sampled at an 1 kHz rate. All active channels had the same measuring range and were fitted to the subject (typically +/- 5 mV). Analog signals were converted to digital signals with a 16 bit sampling resolution and collected by the measuring unit. The signals were transmitted immediately after a single trial to a computer via a Wi-Fi network. After collecting the data, the signals from each trial were stored on a hard drive and later analyzed using the BTS SMART Analyser software. The raw EMG signal was filtered (Butterworth band-pass filter, 10-250 Hz). Next, the full-wave was rectified and smoothed using the root-mean-square (RMS) method with a 100 ms mobile window. Then the RMS EMG signals were normalized to maximal voluntary isometric contraction (MVIC) amplitudes, in accordance with the European Recommendations for Surface Electromyography – SENIAM [Hermens et al., 1999; Konrad, 2005]. All these steps were completed before the players' performance of the series of jumps.

The subjects were instructed to perform the standing vertical jump with a take-off from the Kistler force platform. The MVJ software package [Staniak, 1996] was used to calculate the main mechanical parameters characterizing the vertical jumps such as squat depth in the counter movement phase, peak and mean power, duration of the take-off phase, and jump height.

On the basis of the study results and the knowledge of vertical jump performance a number of significant differences were noted in bioelectrical muscle activity between the counter movement jump with a squat (CMJ) and the other jumps. Particularly interesting were the results of the depth jump (DJ) test. Already at the onset of the DJ the electrical activity of most of the muscles was between 40 and 80% of MVC, which clearly affected the EMG values and characteristics in the subsequent phases of this jump. In the case of other jumps the differences mainly occurred between extreme performance values of individual muscles, as reflected in electromyograms. Some interesting examples included the rectus abdominis muscle and the erector spinae muscle, whose electromyograms clearly differed from the other tested muscles.

After having been given the instructions regarding the type of vertical jump to be performed (CMJ with a deep squat – GCMJ; CMJ with a shallow squat - PCMJ) the volleyball players proceeded to complete the tasks. In the approach phase of the GCMJ and the PCMJ, the "ranges of motion" in lower extremity joins and squat depth were, respectively, significantly larger and smaller than the CMJ values. This affected the further course of internal and external structure of these jumps. In the take-off phase, the mean bioelectrical activity of most muscles in the GCMJ (5 out of 7) and the PCMJ (6 out of 7) differed significantly from the mean bioelectrical activity in the CMJ. The vast majority of recorded kinematic and kinetic parameters were also significantly different from those in the CMJ.

The motivating factor being the crossbar placed over the heads of the jumping volleyball players served its purpose, i.e. to increase jump height and power produced in the take-off phase of the special counter movement jump (SCMJ).

On the other hand, the values of basic kinetic and kinematic parameters, including the main criterion of the effectiveness of movement technique, i.e. jump height, differed significantly from those in the CMJ in most tested jumps. In comparison with the CMJ, jump height was significantly lower in the PCMJ and higher in the SCMJ and - obviously - in WCMJ. Greater power produced during the take-off phase was attained in the DJ, PCMJ, SCMJ and WCMJ, while in the GCMJ it was lower as compared to its CMJ value. Both the articular range of motion in the lower limbs and squat depth in the approach phase differed significantly between the CMJ and the other vertical jumps. The only exception was the SCMJ, in which these parameters similar were similar to CMJ values. There was no single trend of changes in the time of the approach and the take-off phases between the CMJ and the other vertical jumps.

The jump height records obtained in different vertical jump tests with the use of the SMART system and the Kistler force platform were not uniform. However, a certain regularity was noticed. In fact, the jump height in the flight phase recorded with the SMART system software, was 3 to 6 centimeters higher, and this trend was observed for almost all jumps. The only exception was the WCMJ, in which the jump height determined by the SMART system was significantly lower. This was probably due to greater inaccuracies at the stage of marker placement registration in the case of some volleyball players caused by slight differences in their arm-swing.