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Assessment of the Hamstring Load of Female Beach Volleyball Players of a Wider Representative Selection of the U16 Category During the Block Jump Using Surface Electromyography

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ABSTRACT

Blocking in beach volleyball appears to be an axisymmetric movement – in contrast to an attacking strike or serve, which stress the musculoskeletal system unilaterally. When jumping on a block, the player squats and jumps from this position, so we can say that it is a squat with a jump. In the pre-jump phase, the quadriceps femoris, hip extensors (gluteus maximus and hamstrings) and trunk extensors are engaged. This study deals with this game activity from the point of view of unilateral loading and the involvement of individual muscles in the course of jumping onto a block. The aim of the study is to evaluate the involvement of the hamstring muscle group in female beach volleyball players of a wider representative selection under 16 years (n = 11) average age 13.1 (SD = 0.67) and to find out whether this game activity of the individual is axially symmetrical, at the same time we will assess whether the biceps femoris muscle is more involved in the block jump or if it is the semitendinosus. The main method used was surface electromyography (EMG) and descriptive, inferential statistics methods. For the measurements, we used stable conditions, the blockers did not move, they stood directly against the ball, which was thrown by a member of the research team above the level of the net within the reach of the blocker. Results: the jump to the block is laterally symmetrical in 36% of attempts, in 45% of attempts the right leg is more loaded and in 18% the left leg. Biceps and semitendinosus participate equally in 27% of the block jump. In 27% of the group, the biceps femoris is more involved in this movement task, and in 27% of the cases, the semitendinosus is more involved. Despite the description of individual tendencies in the group, statistical significance was not confirmed in any phase of the movement for any muscle. We recommend a more detailed research solution to this issue.

Keywords: unilateral loading; volleyball; blocking; jump squat; landing technique; EMG

INTRODUCTION

Beach volleyball is a one-sided sport, especially when attacking and serving, the dominant side is involved much more. This sport is specific in that each player should be able to perform all individual game activities on the right and left side of the court, which has its regularities mainly in the position of the lower limbs before hitting and the use of the upper limbs, for example, when picking up a ball in a fall (on the right side the ball is picked up with the right hand, on the left side the ball is picked up with the left hand).

The only game activity of an individual that should be symmetrical is the block, it is this game activity of the individual that we will focus on in this post. According to the methodology, blocker training starts in the under 14 or 16 years of age (U14-U16) categories. From the beginning, various imitation exercises are used for training. According to the methodological series, we first practice the block without jumping to a low net and gradually make the exercise more demanding. It is in the U16 category that the block starts to get involved in the game. The regular work of the blocker occurs when the opponent has a stable processing and passing.

A block is a squat with a jump into a raise. The height of the block jump is affected by the absence of arm swing, which is important for maximum vertical jump, as well as the unstable bottom. In this movement, the individual squats using hip and knee flexion, followed by extension at those joints, and then flexion at his/her drop (Padulo et al., 2013).

Here, the knee joint is exposed to high physical demands. As it lies between the two longest joint levers in the body, surrounded by the strongest muscles, these muscles allow the knee joint to remain stable even under rapidly changing forces (Williams et al., 2001).

Dimon (2008) divides the three main groups of thigh muscles: flexors (hamstrings), adductors (pullers) and extensors (ventral group). The main function of the hamstrings is flexion at the knee joint and extension at the hip joint. It is the extensions in the hip and knee joints together with the muscles involved in this movement that are important for running and jumping, i.e., for activities that are crucial to most sports (Dimon, 2008; Yessis, 2005). The main function of the knee joint flexors is performed by the biceps femoris, semitendinosus and semimembranosus muscles. These muscles perform flexion in the knee joint and at the same time internal (biceps femoris muscle) and external rotation (semitendinosus and semimembranosus muscles) (Williams et al., 2001; Živčák, 2004).

During the squat (block), large muscle groups (quadriceps femoris, gluteus maximus, hamstrings and body extensors) are involved in the movement. The extensor muscles must be in co-activation with the muscles of the flexor group, this muscle cooperation develops in the first year of life (Kolář, 2009). The management of this synergy takes place at the subcortical level, if the individual does not achieve it during his/her development, it must be rebuilt at the cortical level of learning (Véle, 2006).

In the study, we will assess the involvement of the biceps femoris muscle and the semitendinosus muscle in the movement task of the block. The aim of this work is to assess the involvement of these muscles of the back of the thighs during the game activity of blocking in players of the wider representative selection in the U16 category.

MATERIALS AND METHODS

Research Group

The research group consisted of 11 female players average age 13.1 (SD = 0.67). The players were selected from a wider representative selection of this age category (U16), based on the acquisition of the selected skill. Under-16 representative selection is made up of 40 players born in 2008–2010. The height and weight of the female players were on average 167.4 cm (SD = 4.8), and 52.4 kg (SD = 4.5). We obtained these data through personal anamnesis and somatometry; the instrument for somatic measurements was a medical scale with an integrated meter for measuring height (Tanita WB-3000, Tanita, Japan). The wider representative selection of girls in the under 16-year category consists of forty players born in the years 2008–2010. These players are nominated by individual clubs based on information sent by the implementation team that takes care of this category.

Methods, Tools

The main method used for data collection was measurement by surface electromyography (here in after referred to as EMG). It is an examination based on the electrophysiological principle, which enables the monitoring of skeletal muscle activity (Krobot & Kolářová, 2011). Its gradual development moves away from invasive needle myography to surface EMG (Hargrove et al., 2007). An Ultium device (Noraxon, USA) was used, along with a Nixon camera system (Nixon, Hong Kong). The Myoresearch program (Noraxon, USA) was used to work with primary data). This software allows reading from 32 channels of the device, also assigns a channel to an individual sensor to a given muscle part. The software further processes the signal by calculating the effective value, moving average, and applying basic digital filters. It stores the measured data in various types of protocols and is able to export data in various formats. The camera system together with the Myoresearch program allows you to divide the movement into individual phases and interpret the data in these sub-parts of the movement.

Research Design

The measurement itself was carried out on 14/01/2023 during the morning training blocks of the U16 representative camp in an inflatable hall with beach volleyball courts (BC Strahov, Prague). The study was conducted: after the informed consent of the players, in accordance with the Declaration of Helsinki, the ethical standards of the university were followed. The study was implemented with the consent of the coaches of the given representative selection of the Czech Volleyball Association.

In preparation for the measurements, the skin over the belly of the muscle was shaved and cleaned with alcohol in order to reduce the skin impedance to 5 kΩ. Bipolar surface electrodes (distance between electrodes 1.2 cm) were aligned with the longitudinal axis of the muscle according to SENIAM recommendations (Hermens et al., 2000). Electrode placement was confirmed using manual muscle testing.

All players warmed up with the start of testing. Subsequently, the players completed tests to assess the physiological length of the assessed muscles according to Janda (2004). One player had a negative evaluation of this test; therefore the final number of tested players is 11. These 11 players were in a good state of health, without having suffered injuries of a more serious nature during the last 6 months.

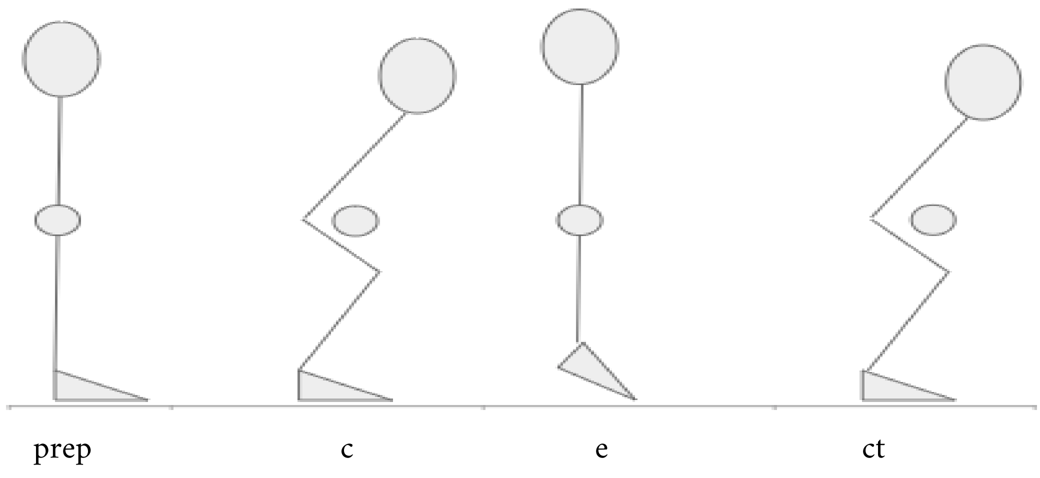
The movement task itself, which led to the collection of primary data, proceeded as follows. The tested person always faced the coach (he stood on the other half of the field, behind the net). The ball was thrown by the coach (in the axis of the body) and the tested player (blocker) had the task of blocking it. Because the ball was thrown in the axis of the body, the blocker did not block the ball outside the axis of the body, did not have to move etc. – so she performed a block from a squat, a knee-bend. This movement task was tried by each player (5x) and then followed by 5 test repetitions. This activity was filmed by cameras from the side and the front. Subsequently, the 3 best attempts of each player were selected (on the basis of observation according to the correct execution of the task), which were used to obtain data from the EMG device.

As part of the research, we measured the EMG involvement of the right and left side of the blocking player during the aforementioned movement task. So, we looked for differences in the values of the right and left half of the body. We assumed that there is no difference in the involvement of the muscles of the right and left half of the body. Maximum free contraction according to Janda (2004) was not the subject of our research, because we did not monitor the involvement of individual muscles compared to the maximum.

After measurement, the electromyographic signal was adjusted by rectification and smoothed with a mean square value (Root Mean Square parameter) using a window of 100 ms for evaluating muscle timing (Konrad, 2005). From the adjusted signal, 3 stable and best performed movement cycles were selected by expert assessment.

We divided these cycles into individual phases and from this we obtained the values of the involvement of the evaluated muscle parts in one step. We divided the movement task into the following phases: concentric (c), eccentric (e) and contact phase (ct), see Figure 1.

We transformed the EMG data obtained in this way using the Myoresearch program into the so-called Standard EMG report and Symmetry Report protocols. We further subjected the Standard EMG report to an analysis with the marking of key points (the so-called Point of Interest), which shows individual values in individual parts of the movement.



Note: concentric (c), eccentric (e), contact phase (ct),

Figure 1. Division of the movement task into individual phases

Statistical Data Processing

To evaluate the data, we used methods of descriptive and inferential statistics (frequencies, percentage representation, respectively Shapiro-Wilk test, T-test, Man Whitney U test). We analyze the tendencies of individual players, in individual phases of movement in terms of muscle involvement, using frequencies and numerical operations with percentages. The tools were: software Microsoft Excel 2020 (Microsoft Corporation, USA) and Statistica PRO trial version (StatSoft, CR).

RESULTS

The results are divided into three parts. The first part is devoted to the tendencies of the probands during individual experiments. We assessed the results after data transformation into the Standard EMG Report - Point of Interest (see Fig. 2 and 3, as example of one person). We evaluated the individual sub-phases of the movement task using frequencies. Figure 2 shows the course of the entire test with five movement cycles for the individually assessed muscles. The preparatory phase is also indicated in the report. From these five cycles, the three most successful in movement according to the image recording were selected by an expert selection. These ones were assessed.

Tendency of Individual Probands in Terms of Muscle Involvement During Blocking

During the individual phases of the movement task, the following tendencies appear in the individual trials of the probands. The jump to the block is laterally symmetrical in 36% of attempts, in 45% of attempts the right leg is more loaded and in 18% the left leg. Biceps and semitendinosus participate equally in 27% of the block jump. In 27% of the group, the biceps femoris is more involved in this movement task, and in 27% of the cases, the semitendinosus is more involved. 18% of attempts have a disproportion in the involvement of individual muscles. During this activity, we observe a disparity in the involvement of the semitendinosus, there are big differences in the work of the right and left, specifically in 72% of attempts. Figure 3 shows the values of individual cycles at the time of recording stop.

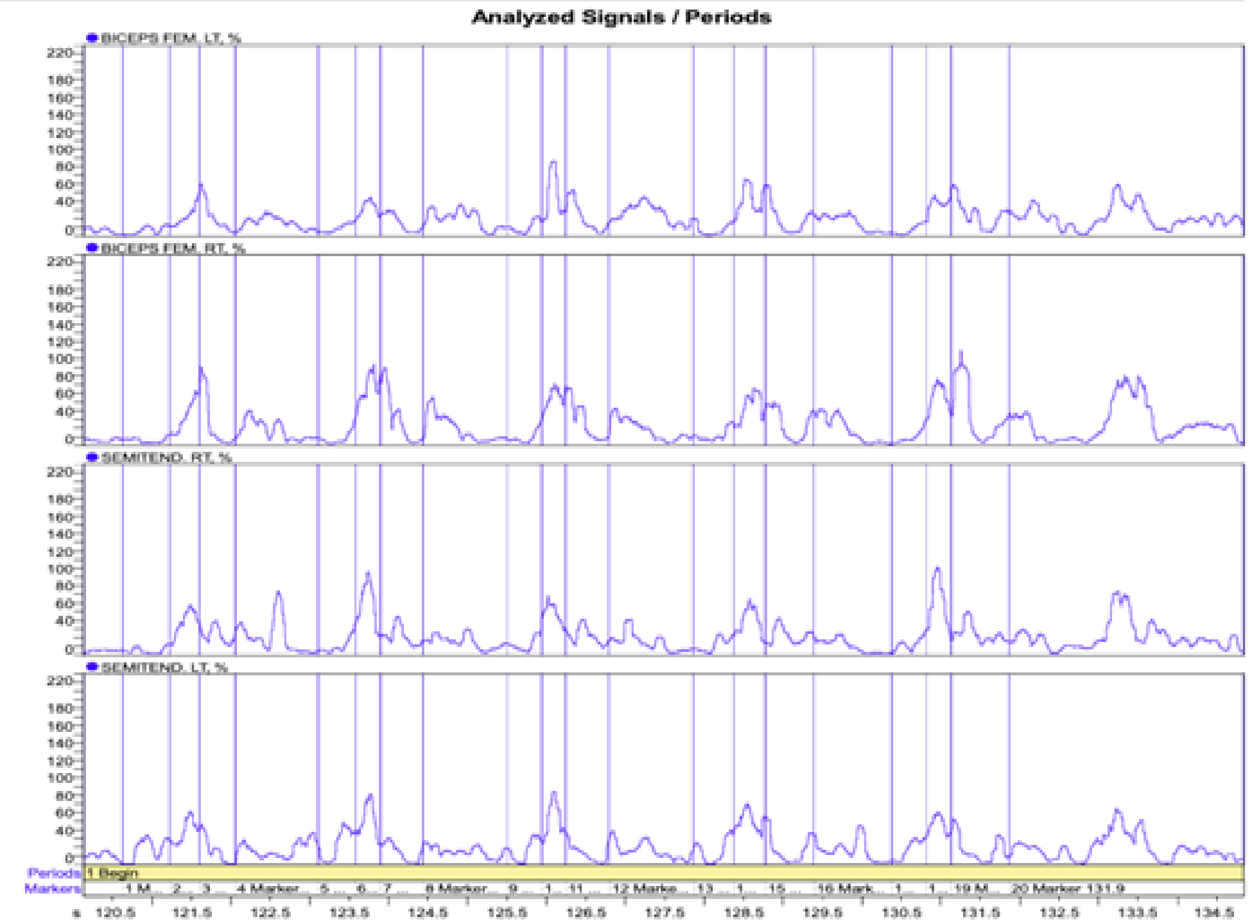


Figure 2. Standard Analysis report – Point of interest – the course of the entire test (example of one person)

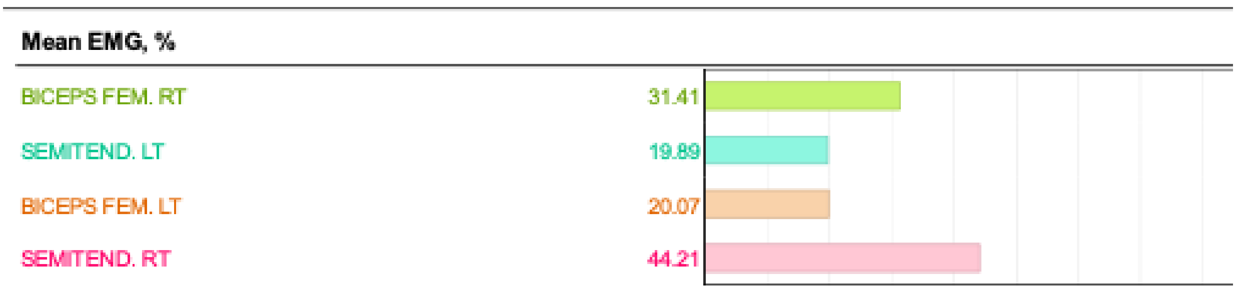


Figure 3. Standard Analysis report – Point of interest – eccentric phase (example of one person)

Average and Absolute Values During the Entire Test

We also present the results of average and absolute values from individual measurements. We obtained these data from the generated Symmetry report, which includes a comparison of the work of muscle groups (see Figure 4) as well as the average and maximum values measured during testing. An example is given in figure 5 - the average of individual muscles and 6 - absolute values of individual muscles. These graphs also show differences in the work of individual muscle groups in percentages.

Average involvement of muscle groups in our set. 45% of the set involves more left biceps, 27.5% of cases involve more left biceps and the same percentage engages biceps symmetrically when jumping to the block. On the contrary, in 64% of the group the right Semitendinosus is involved more, in 27.5% the left one is involved more and in 18% these muscles are involved symmetrically. In the cooperation of both muscle groups, we find it interesting that almost half of the group has a more active left biceps together with the right semitendinosus, so probably these muscles take over the function of each other. Three probands overload the right leg, two the left leg, and one proband engages the hamstring groups symmetrically.

When assessing the absolute values of the individual parts during testing, we found that the right side achieves overall higher values, this applies to the biceps from 54% and for the semitendinosus from 64%, otherwise we again see a tendency to take over the functions of the muscles. In one case, symmetry was demonstrated in the maximal activity of the assessed muscles.

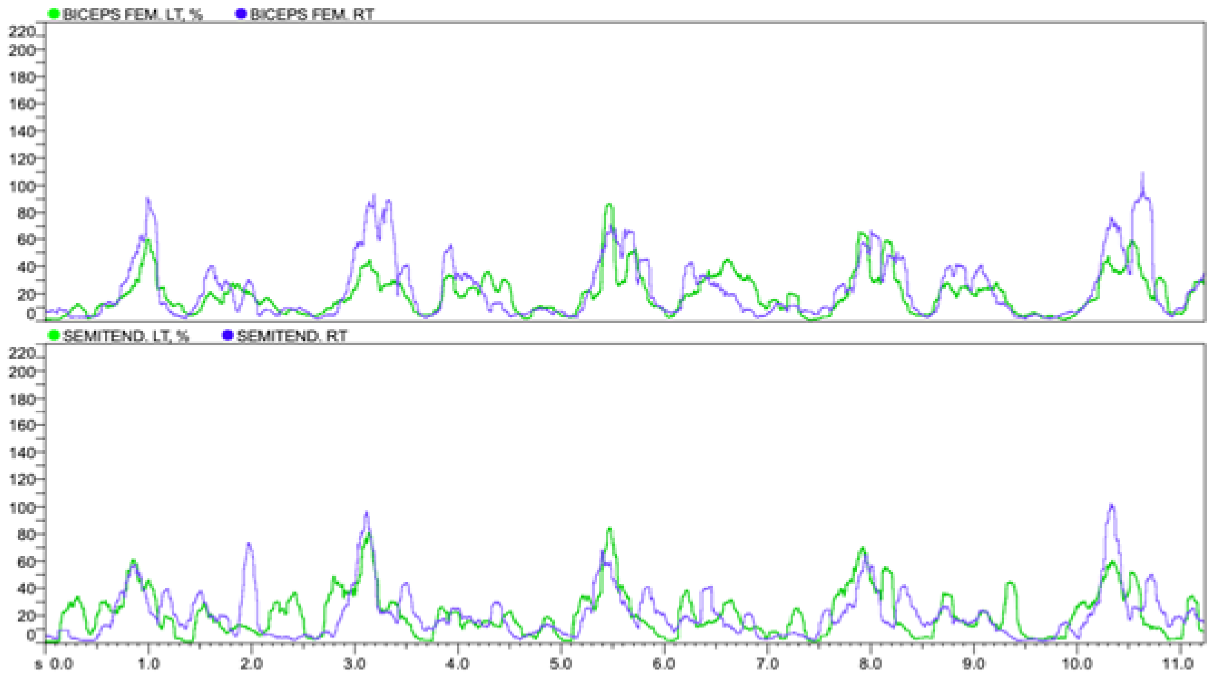


Figure 4. Symmetry report of the entire test process (example of one person)

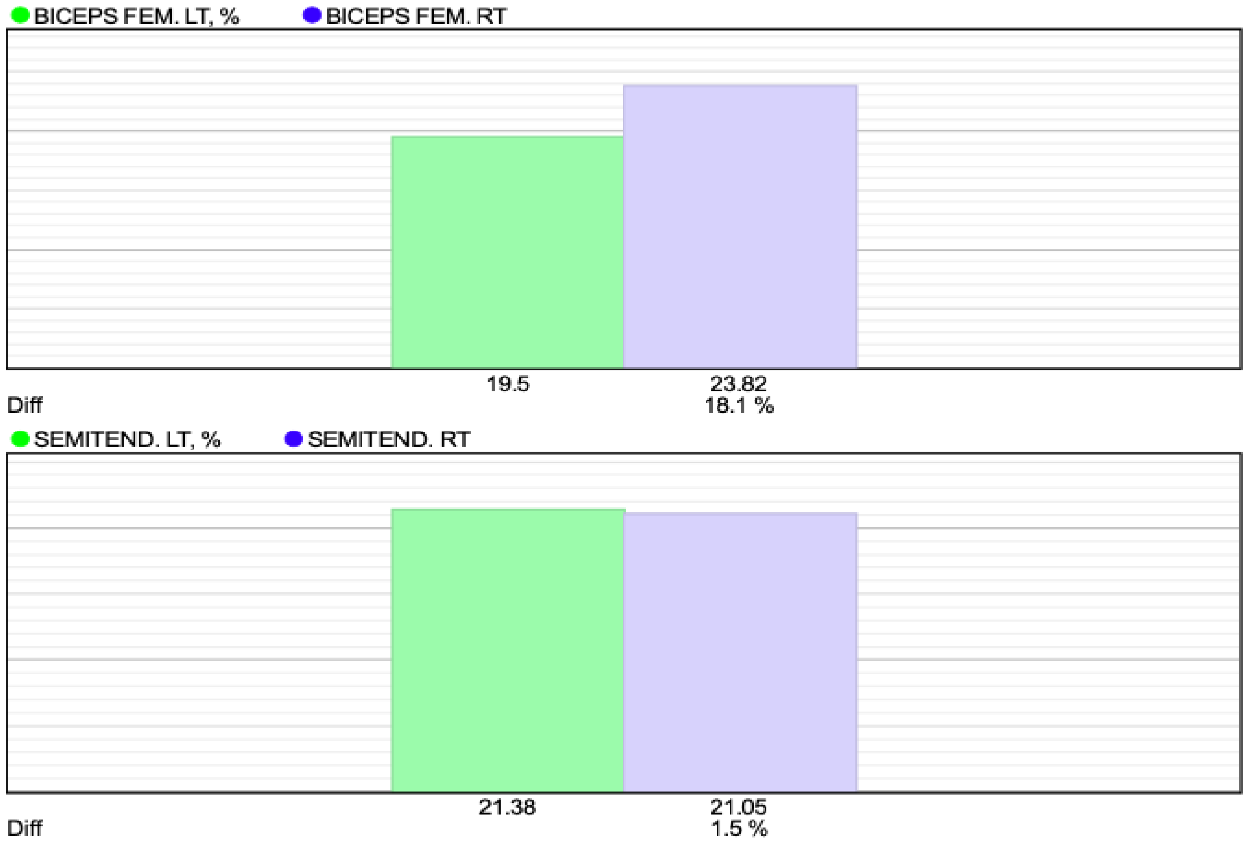


Figure 5. Symmetry report – average values from three trials assessed (example of one person)

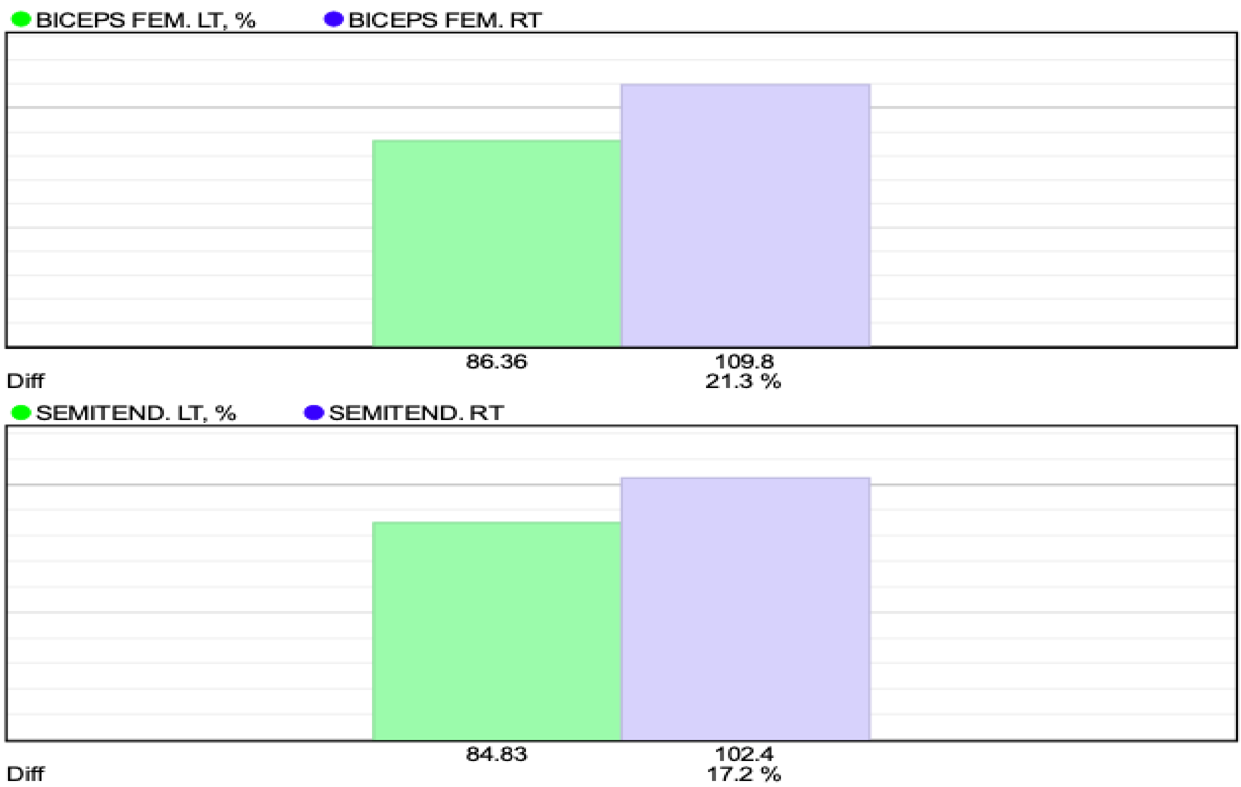


Figure 6. Symmetry report – Absolute values from three trials assessed (example of one person)

The Involvement of the Biceps Femoris Muscle and the Semitendinosus Muscle During Blocking

In the concentric phase, there is no difference between the involvement of the biceps femoris (p=0.812) or the semitendinosus (p=0.717). In the eccentric phase, there are no differences either in the biceps femoris (p= 0.081) or in the semitendinosus (p= 0.644). In the fall phase, the right side is also not statistically different from the left (p= 0.174 for the biceps, p=0.664 for the semitendinosus).

Despite the different involvement of individual muscle parts of individual probands, calculations do not show statistical significance in any phase for individual parts. Statistically, there is no difference in the involvement of the right and left groups of hamstrings in the group of players of the wider national team.

DISCUSSION

In our study, we assessed the involvement of the hamstrings in the block jump in U16 female players from the point of view of unilateral loading. No one has researched this problem directly in beach volleyball. The study has its limitations mainly in the limited research sample (n = 11), furthermore, in the impossibility of comparing our results with other researches. We can only discuss descriptive injury studies. Another limitation is the different methodology for working with EMG. Since we are interested in the activation of the right and left sides, we do not work with the maximum voluntary contraction, which is used in most of these types of studies.

Tendencies of muscle involvement of individual players in the course of the movement task were described above. The file differs in this respect from our expectations. The block jump is laterally symmetric in 36% of the trials, the right hamstrings are more loaded in 45% of the trials, we expected the right side to be overloaded in the majority of the set. During this activity, we observe a disparity in the involvement of the semitendinosus muscle, there are big differences in the work of the right and left, specifically in 72% of attempts. On the basis of these results, we observe tendencies to take over the function between the biceps femoris muscle and the semitendinosus muscle.

In the average involvement values for individual probands, it can be seen that a frequent phenomenon is the compensation of the higher activity of the biceps femoris muscle on the left side by means of the higher activity of the right semitendinosus muscle.

Based on the assessment of the absolute values measured as part of the testing, we can state that the hamstrings on the right leg reach the maximum of higher activities. The inference did not show a statistically significant difference between the involvement of individual muscle groups. It can therefore be concluded that the right and left halves of the body are equally involved when jumping for a block, if the blocker has time to prepare for the block.

The same load on the right and left half of the body is one of the important factors, due to which muscle imbalances and other types of injuries do not occur. Therefore, an important factor in injury prevention is the technique of execution of the jump and drop when blocking. Sole et al. (2017), in their retrospective analysis, describe injuries in female volleyball players. It is concluded that the most common injury was in the knee area (left = 7.5%, right = 12.0%). The study by Khorzoghi et al (2021) agrees with this (2021). It looked at injuries in Iranian youth volleyball players. Most injuries are in the shoulder and back area. A relatively high percentage of injuries also occurred in the lower limb area, with most injuries occurring in the knee area. Injuries occurred most often during training (75%) and more than half of the injuries occurred without contact with another person. This supports our thesis that the preparatory phase before jumping onto the block is important for the correct involvement of individual muscle groups and the associated correct rebound and drop technique. Soylu et. al. (2020) addressed the relationship between balance, knee joint strength, jump height and injury risk in female volleyball players. His study showed a significant relationship between jump test values and knee flexion. As part of prevention, it is therefore necessary to pay attention to the compensation of the knee joint flexors in the training process.

A similar issue using EMG is mainly dealt with by Padulo et al., who monitors the activation of the biceps femoris muscle during various types of jumping exercises (2013). The jump, which is also used for blocking in beach volleyball, can therefore lead to injuries in the case of poor technical execution of the block (jump, drop). According to Padulo et al. (2013) a hamstring injury is common, it occurs with poor drop technique after a jump. The symmetrical involvement of the muscle parts, in our opinion, is an important prerequisite for the correct technique of the drop of the blocker.

CONCLUSION

From the above findings of our investigation, it can be concluded that: if the blocker has time to relocate and blocks in the axis of the body, his muscle activity is laterally symmetrical; in many cases the semitendinosus muscle took over the function of the biceps femoris muscle. Recommended for practice: to use our study for a deeper kinesiology knowledge of individual activities in beach volleyball and subsequent high-quality setting of preventive and compensation programs. We recommend further scientific investigation of the issue on a larger research sample in these areas: load on the blocker's hamstrings after the move and under greater time pressure; activation of individual muscles and the search for the causes of different involvement of individual muscles during the movement task.

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