ELECTROMYOGRAPHY DETECTION OF MUSCLE RESPONSE IN MUSCULUS QUADRICEPS FEMORIS OF ELITE VOLLEYBALL PLAYERS ON DIFFERENT TRAINING STIMULI

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SUMMARY

The aim of this research was the detection of bioelectric potential generated in the muscle cells of volleyball players and muscle stimulation, using the electromyography method, during different training stimuli. A set of variables was applied for EMG measurement: measuring bioelectrical activity prior to any training stimulus, measuring after the coordination exercises (athletic – coordination and SAQ exercises, measuring after the proprioception exercises (balance maintaining at the profiboard for 1 minute) and measuring after a thrust at the leg press and a half squat in the maximum strain regime. The study was conducted with 16 players from Serbia National Volleyball Team, Champion of Europe. For the results analysis at the multivariate level, we used the discriminant descriptive data analysis method. After the results analysis, which shows the differences of the measurement values before and after the stimuli and after the proprioception variables at the multivariate level, it can be stated that there are statistically significant differences (p= 0.018311). The conclusion is that the coordination exercises do not produce the acute effect of increasing the muscle bioelectrical activity, Power and strength exercises created statistically significant change in the bioelectrical activity and as such they justify their role in the warming phase, i.e. the preparation of the neuromusculature apparatus for the work with the additional load (weights) in the specific conditions and the requirements of the training process of the elite volleyball players.

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**Key words:** emg, muscle, elite volleyball players, detection

### INTRODUCTION

Preparation this paper, we were guided by the idea of the contribution to the training stimuli analysis and application, i.e. programmed exercises for the development of the complex coordination area and power and strength area, in an effort to indicate, by using concrete and exact information, the directions of the analytical and methodical effects.

Conceptual definition of coordination and the terminology available in the literature have a wide application range, resulting in a number of difficulties and perplexities regarding the definition and perception in methodology and practice, as well as in the theory of Sports Science (Kinesiology).

The definition of coordination implies synergistic activity of the CNS and skeletal musculature, with the aim of a controlled organization of movements in terms of energy, time and space, into one integral whole (Guissard & Ducheteau, 1990; Santos et al., 2008).

This problem becomes even more important when we consider the correlation with other abilities. In this case, power and strength.

In the modern, primarily elite volleyball, in addition to the undisputed SAQ (speed, agility, quickness) system, coordination abilities are assuming a dominant role over other abilities from the complex structure of motor abilities.

In competitive conditions, which imply that the players are perfectly trained in terms of the technique and tactics, and that the speed-quickness abilities are at a high level, the parameters deciding the winner are often in a direct correlation with the balance and coordinated movements in the key moments (defence in the field, service, hitting quick balls, lifting of the passive balls, depending on the balance in the initial position and the movements coordination while sprinting - reducing the errors to a minimum).

Explanation of the dynamic and frequency changes in the expression of the speed and quickness movements is in the understanding of the central nervous system functions (Bevilaqua-Grossi et al. 2005a). Muscle force is determined by the level of the individual muscle fibres activation. Coordinated movements of multiple muscle groups depend on the level of the intermuscular coordination development, while the coordination effect of the individual muscles is
conditioned by the intramuscular coordination (Bevilaqua-Grossi et all. 2005a; Filipović et all., 2009).

In view of these observations and a multitude of information regarding the diagnostics and methodology of the quickness, agility and speed development (Starosta, 1987), this study is dedicated to the diagnosis of the coordination stimuli and their responses, expressed in the contractile, tonus and bioelectric activities of the outer, inner and middle head (vastus lateralis, vastus medialis and vastus intermedius) of the four-headed muscle of the femur (m. quadriceps femoris), of the volleyball player, the main movement performer (extensions in the knee joint), in bouncing, a basic movement in volleyball.

The aim of the research is to determine, in the exact, non-invasive manner, the online response to a given movement stimulus, i.e. to analyze the impacts of coordination exercises and determine the differences in relation to bioelectrical activity resulting from the application of the exercises for the power and strength development. We used electromyography, which detects electric potential, generated in muscle cells, in an effort to establish, during this research, how and to what extent the coordination exercises and the strength and power exercises stimulate the muscle, i.e. evoke its bioelectric activity. From this point of view, we were interested in answering the question whether coordination exercises can be used as preparatory exercises (which is often applied in volleyball) for the training methods aimed at the power and strength development, i.e. whether they can adequately and validly warm the myology and syndesmology apparatus for the power and strength development training in relation to warming through the exercises from that type of activity (exercises with additional load, or one’s own body under the influence of gravity). EMG analysis is often used in the analysis of human or animal movement, i.e. in biomechanics. EMG is also a useful method in the diagnosis of neurological and neuromuscular problems. There is a difference between clinical EMG, where intramuscular (needle) electrodes are used, recording electrical signal inside the muscle, and electromyography, which uses surface electrodes (SEMГ – surface electromyography), which are placed on the skin surface. However, spontaneous muscle activity cannot be recorded by the surface electrodes. This type of electrodes is used in kinesiological analysis of muscle activity. In this research, surface bipolar electrodes were used, because they are not invasive.
Physiology of electromyographic signal

The impulse, delivered to the motor neuron, is necessary for muscle fibres so the muscle can produce the force. The CNS activates the motor neuron, whereby the electrical impulse travels down the motor neuron to each synapse (Macek, Lebar & Mlikavc, 2005). Synapse is a communication connection between two neurons, since at that spot signal transmits from one neuron to the other. The action potential is created in the synapse. Position of the neurons leads to the changes in the membrane, which has the openings for passing the ions, i.e. the electrically charged particles. This charge arises from the differences in the number of protons and electrons. During the passage of ions through the membrane, the action potential is created, which does not occur at once in the whole motor neuron, but the part of the motor neuron membrane is needed. The action potential, upon its occurrence, travels throughout the membrane. Traveling of the action potentials down the axon, or up the dendrite, represents the basis for the information transmission mechanisms in the brain (Lowery, Nolan & O’Malley, 2002; Radovanović & Ignjatović, 2009).

METHODS

A set of variables was applied for EMG measurement: measuring bioelectrical activity prior to any training stimulus, measuring after the coordination exercises (athletic – coordination exercises lasting 10 minutes, measuring after the proprioception exercises (balance maintaining at the profiboard for 1 minute) and measuring after a thrust at the leg press and a half squat in the maximum strain regime.

Each measurement was performed three times, for the given subject and the basic statistical parameters were calculated.

The study was conducted with 16 senior volleyball players from Serbia Volleyball Team, Champion of Europe, aged 28.89±5.31 years, height 199.50±6.47 cm, weight 90.23±10.10 kg. Measurements were conducted in Serbian Institute for Sport and Sports medicine, BioIRC research laboratory and fitness room of the sports center Impuls, Belgrade.

The device used during the experiments for filtering and amplification is iWorx ETH 256 two channel combination bridge ECG/EMG/EEG amplifier. Data acquisition was performed by NI6008, 12 bit 10kS/s multifunction DAQ.

Statistical data analysis was performed using data processing programme SPSS 15.0 Windows. We applied the method of measuring EMG response by bipolar surface electrodes, in order to obtain the information on the continuity or the lack of continuity in the so-called motor (driving) unit. We note that the motor unit consists of the station in the anterior horn of the spinal cord, motor axon or
neurite, motor plate and muscle fibres innervated by that axon (Bevilaqua-Grossi et al. 2005b; Bompa, 2001).

Using the bipolar combination we placed two electrodes on the skin, in the area of the central abdomen m. vastus lateralis and m. vastus medialis, and the third on the electrically neutral spot (tendon border m. vastus intermedius and m. rectus femoris) (Bompa, 2001, Radovanović & Ignjatović, 2009). Measurement was conducted immediately after each stimulus, i.e. immediately after the exercise. Each measurement was repeated in three series. Points for placing the electrodes were determined for each subject separately, according to the morphological structure. The action potential values were detected in the phase of maximal voluntary contraction and complete muscle decontraction, as well as muscle activity in the meantime, which is clearly evident in the diagrams (figures 1, 2, and 3). This combination required the amplifier with the task to register the difference between the two electrodes. Each signal common to the electrodes, is weakened by the amplifier. The common signals, weakened or rejected, can be represented by a logarithm or a linear presentation (Gerdle et al., 2000).

Voltage, or amplitude, which is used for measuring from peak to peak is shown in millivolts (mV), as a function of time expressed in milliseconds (ms). It is important to note that, during the experiment, we addressed special attention to several specific requirements for placing the electrodes on the muscle, such as: motor plate, relative movements of the abdomen and the fixation of the preamplifier cable (Hermens & Freriks, 1999).

Figure 1. Bioelectrical activity of muscles, after performing coordination exercises
RESULTS AND DISCUSSION

The intention was to investigate the effects of the coordination, proprioceptive exercises and the exercises for the lower extremities power and strength development (m. quadriceps femoris) on the bioelectrical activity in muscles and to indicate the real effect and online adaptation immediately after the exercises.
Thus we wanted to elucidate this problem in an exact manner, without unconfirmed hypothetical positions, which occur in training practice, and to indicate to coaches and sport experts what is really happening in a muscle during this type of activity. For the results analysis at the multivariate level, we used the discriminant descriptive data analysis method.

After the results analysis, which shows the differences of the measurement values before and after the stimuli and after the proprioception variables at the multivariate level, it can be stated that there are statistically significant differences (p= 0.018311).

Table 2 Multivariate analysis – proprioceptive exercises

<table>
<thead>
<tr>
<th>Test</th>
<th>Value</th>
<th>F</th>
<th>Effect</th>
<th>Error</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wilks</td>
<td>0.837595</td>
<td>3.69</td>
<td>3</td>
<td>55</td>
<td>0.018311</td>
</tr>
</tbody>
</table>

That signifies that the experimental treatment affected the changes of the subjects’ bioelectrical muscle activity.

Table 3 Multivariate analysis – power and strength exercises

<table>
<thead>
<tr>
<th>Test</th>
<th>Value</th>
<th>F</th>
<th>Df1</th>
<th>Df2</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wilks</td>
<td>0.743475</td>
<td>3</td>
<td>7</td>
<td>53</td>
<td>0.014123</td>
</tr>
</tbody>
</table>

After the analysis of the results, which shows the differences of the measured values before and after the stimulus and after the power and strength variables at the multivariate level, it can be stated that there are statistically significant differences (0.014123). Analysis of the measurement results, after the coordination variables, did not indicate any statistical significance (p=767432), which leads to the conclusion that the coordination exercises do not evoke any significant bioelectrical activity in the muscles. This information can be valuable guidance on how and in which situations these exercises should be applied. The purpose and the activities of future research could go in that direction. The idea is to create a system of detection of the given abilities is every phase of the training, i.e. to perceive the effects on the muscle activities. In the future, the activities will be focused on the research of the cumulative effects in the muscle, as well as on the expansion of the diagnostic and analytical procedures for the other types of subjects, in order to determine the differences and address coaches and sport experts in terms of the directions in which the coordination development method should be guided, as well as to combine coordination methods with methods for the development of other motor abilities.
CONCLUSION

The conclusion is that the coordination exercises do not produce the acute effect of increasing the muscle bioelectrical activity, and as such, for example, cannot be independently used as a neuromuscular exercise (warming) for the power and strength training (Radaković et al., 2011) or the quickness and speed properties development training. Of course, their significance is not reduced by this and the effects are in the domain of the CNS, motor learning and adoption of motor skills, as well as the range of the abilities responsible for the movements coordination, at the neuromuscular level.

Power and strength exercises created statistically significant change in the bioelectrical activity and as such they justify their role in the warming phase, i.e. the preparation of the neuromusculature apparatus for the work with the additional load (weights) in the specific conditions and the requirements of the training process of the elite volleyball players.

Proprioceptive exercises created statistically significant difference in the bioelectrical activity, which primarily justifies their preventive and rehabilitative role in the training process and specifically programmed exercise.

Of course, the question of cumulative effects and muscle adaptability arises, related to the research from the domain of the mentioned abilities, which can be the aim of the research of some future studies in this area. Also, new experimental areas can open, from the field of coordination and its correlation with other abilities of the motor abilities area.
We endeavored to present a set of experimental and numerical results, giving the base for the future testing within this complex area, which could provide the coaches and sport experts with the estimates of the coordination abilities in different, especially situational conditions. This type of approach to this issue opens numerous possibilities in the innovation of the analytical and diagnostic procedures, changes in the motor stereotypes and adopted skills, as well as in the competitive efficiency of athletes.

REFERENCES


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