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EMG SIGNAL ANALYSIS OF SELECTED MUSCLES DURING SHOTS AND PASSES IN BASKETBALL

ABSTRACT

During testing, the arm muscles bioelectric activity was compared of basketball players at the initial and focused stage of training. The objective of testing was to analyse EMG signal during free throw and chest passes. To perform testing and analysis of results, the EMG system of NORAXON company was applied, which recorded the signal amplitude and activity time of flexors and extensors of the elbow joint. The following muscles were tested in case of twenty five basketball players from AZS Academic Sports Club of Opole University of Technology: triceps brachii muscle and biceps brachii muscle of the right and left arm. Testing showed significant differences between the groups in the average bioelectric activity, skill level and move duration time. Players who were in the focused stage of training showed smaller average activation of muscles than their less experienced colleagues. It was also proved that their skills are on higher level, and passes and shots are made in a shorter time. EMG signal amplitude reached the highest values in a peak phase of muscle activity; for both activities it was the moment of arms straightening in elbow joints.
Key words: basketball, EMG signal, technical skills, motor patterns, move duration

INTRODUCTION

The success in basketball game is very complex. Each player should have well developed mental properties, proper somatic build, top level of technical skills and motor abilities coordination (Naglak 1996).

In this study it was decided to use EMG to analyze bioelectric activity of basketball players' arm muscles. EMG signal analysis allows to get information on the bioelectric tension and time when the muscles remain active (De Luca 1997, Borysiuk, Zmarzły 2005).

Basketball skills by means of EMG was tested by Stuart Miller (1999). He compared accurate and off-target shots. Inaccurate attempts during testing were related to later activation with regard to the ball and the activation period was longer than in case of accurate shots. Unsuccessful attempts in majority were also connected with larger activation variability.

EMG during a free throw was tested by Zachry, Wulf, Marcer, Bezodis (2005). They wanted to check which type of thrower's attention focus, internal (wrist movement) or external (basket hoop), brings better effects. They came to a conclusion that the throw was more accurate if the external attention focus was accepted. In addition, external focus of attention generates smaller muscle activation measured by EMG, which causes that the movement is more economic.

EMG was also used in testing to measure the assessment of skills acquisition, Abe S., Nozawa T., Kondo T. (2009). They proposed a hypothesis that visualization of EMG signal difference between the expert and beginner, as well as information of beginner's error in actual time, speeds up the learning process. Preliminary results showed, that suggested method was effective, especially in the initial phase of training.

It was also taken into account that the training process should be focused to optimize moves of players. Kędzior et al (1992) drew the attention to so-called reverse issue of optimization. It consists in identification of criteria which were selected by optimally working system during performance of a specific action. Having that in mind, the motion technique of high class players is worth investigating , to be able to determine a so-called "master's pattern".

Analysis of subject matter related literature shows that currently there is a shortage of publications in the field of muscle bioelectric activity determination during motor activities in basketball.

MATERIAL AND METHODS

The objective of this study was to investigate, whether there are differences in skills and bioelectric activity of muscles of basketball players at the initial and focused stage of training during free throw and chest passes. Tested players belonged to AZS Academic Sports Club of Opole University of Technology. Evaluation of the move structure was made with application of EMG. Based on EMG analyses, the move patterns were also determined for basketball players that demonstrate the best skills.

The analysis covered muscle activation (EMG) and move duration from the beginning of muscle activation until the target was reached. Particular attention was paid to disproportion in share of individual muscles during movement. EMG testing involved flexor muscles (musculus biceps brachii) and extensor muscles (musculus triceps brachii) of right and left arm elbow joint.

Research Hypotheses:

Technical skills in shots and passes will differ significantly depending on the training phase.

Basketball players' skills with various training experience will demonstrate high variability of EMG signal, and non-dominant limb will have higher bioelectric activation than the dominant one.

Move duration will be shorter in case of more advanced players.

Tools

The testing tool applied was a four-channel EMG system of the Noraxon company, which records the bioelectric activity of muscles, so-called dynamic EMG in training conditions with the wired communication between preamplifiers and the signal collecting unit. A digital signal recording EMG parameters is sent using telemetric transmission to the computer. Pre-gelled surface electrodes of SENIAM type were placed between the motion point and tendon trailers, along the longitudinal axis of the muscle. Data analysis was made with MyoResearch XP MT 400 software.

Research material

The analysis considered results obtained by 25 players of AZS Academic Sports Club of Opole University of Technology. Twelve from a group which were at the beginning stage of training and thirteen on a focused training program. Beginners' age was $\bar{x}$ = 17.64 ± 2.4 years, whereas the focused stage players' $\bar{x}$ = 24.61 ± 3.9 years. Practice period of less advanced players was $\bar{x}$ = 2.07 ± 1.8 years, and of more advanced ones $\bar{x}$ = 10.3 ± 2.84 years. Taking into account the parameters of height and weight, in case of beginners they were $\bar{x}$ = 179.43 ± 9.36 cm and $\bar{x}$ = 70.36 ± 12.34 kg, and advanced players: $\bar{x}$ = 192.23 ± 9.91 cm and $\bar{x}$ = 88.69 ± 14.45 kg.

Tests included two attempts. The first was to make 20 free shots to the hoop, and the second 30 passes to the target from 7 m distance. During test players had EMG equipment connected to test the bioelectric activity of muscles. The electrodes were placed on biceps brachii and triceps brachii muscles of the right and left arm.

Fig 1. Free throw attempt

Fig 2. Two-hand chest pass attempt

Equipment used for testing was manufactured by NORAXON series MyoTrace 400 with surface electrodes. In order to assure testing reliability only right-handed players were tested. During the analysis of EMG activation each test attempt was taken into account separately, measuring the muscle activation level and move duration.

Fig. 3. Arrangement of electrodes during EMG testing – front view

Fig. 4. Arrangement of electrodes during EMG testing – rear view

TESTING RESULTS

Players on a focused training stage have higher level of tested skills. With respect to the free throw, the average amount of goals in case of more experienced players is $\bar{x}$ = 16.08 ± 2.68 of accurate shots out of 20, while in case of less experienced players this value is $\bar{x}$ = 12.46 ± 3.62. If only accurate shots were taken into account, then in 30 attempts scored from 0 to 3 points, where the highest score value was given for the most accurate pass, beginners scored $\bar{x}$ = 73.14 ± 5.86 points, compared to $\bar{x}$ =77.84 ± 4.09 points of players more advanced in practice. Comparing tested technical skills at individual stages of training, in case of the free throw it can be observed the statistical validity was at p=0.008, whereas in case of accurate passes it was p=0.029.

Comparing the maximum activation level of muscles (EMG) during the shot in both groups it can be noticed that activity of muscles in the left arm is higher in case of less experienced players, and the opposite in case of the right hand. In case of shots, the essential statistic differences between groups, $p<0.05$, occur in left limb muscles. In triceps brachii p=0.007, whereas in biceps brachii p=0.088, so the level is close to statistical validity.

In the right arm the statistic validity for triceps brachii is p=0.533, and for biceps brachii p=0.68. If we take into account the bioelectric activity of muscles during passes “p” value oscillates between 0.356 and 0.637, which proves the lack of statistic validity.

Results of medium EMG muscle activation during move from the beginning of muscle activation until the target is reached, are smaller on the focused stage of training in both skills. In addition it can be also noted, that more essential from the statistics point of view are results of left arm muscles. The results speak well on better trained group, which may prove better symmetry in practice. Duration of movement in case of players at a higher training level was shorter. In case of shots the difference was 0.116 s, and in case of passes 0.198 s.

Table. 1. Muscles bioelectric activity of players at the initial and focused stage of training based on a men's basketball team of AZS Academic Sports Club at Opole University of Technology

Variables	Activation average initial stage	Activation average - focused stage	t	p	Standard deviation initial stage	Standard deviation focused stage
Average maximum of cycles						
Shots						
left triceps brachii [μV]	803.222	310.500	3.198940	0.007648	396.8759	164.1123
rigft biceps brachii [μV]	424.778	465.667	-0.421474	0.680680	205.7840	158.3348
left biceps brachii [μV]	601.944	390.458	1.854127	0.088451	258.4426	169.5855
rigft triceps brachii [μV]	917.889	1044.250	-0.641796	0.533074	396.6182	339.8212
Passes						
left triceps brachii [μV]	1001.278	915.250	0.483447	0.637480	382.2644	285.8968
rigft biceps brachii [μV]	456.111	584.417	-0.813741	0.431644	185.8613	348.4928
left biceps brachii [μV]	646.056	554.583	0.647945	0.529223	313.1493	217.0103
rigft triceps brachii [μV]	1248.944	991.542	0.960420	0.355797	435.9343	535.2020
Average activation of cycles						
Shots						
left triceps brachii [μV]	123.122	60.192	4.359654	0.000929	38.4435	13.0005
rigft biceps brachii [μV]	98.683	104.142	-0.425735	0.677837	18.2369	26.9921
left biceps brachii [μV]	170.800	105.621	2.370861	0.035346	69.0896	32.1355
rigft triceps brachii [μV]	169.756	153.850	0.680048	0.509382	48.1004	39.5304
Passes						
left triceps brachii [μV]	223.489	159.288	1.696346	0.115584	92.4719	48.0731
rigft biceps brachii [μV]	158.222	141.108	0.626382	0.542797	44.9472	54.2628
left biceps brachii [μV]	197.667	146.142	2.368004	0.035530	41.6872	39.2907
rigft triceps brachii [μV]	280.500	182.842	2.273842	0.042145	80.3788	78.9101
Average duration of cycles						
Shots						
activation duration [s]	1.981	1.865	1.251715	0.234524	0.2418	0.0893
Passes						
activation duration [s]	1.132	0.934	3.774429	0.002650	0.1298	0.0654

In order to determine movement patterns of individual skills it was demonstrated that EMG signals of right-handed player who threw the most accurately – initials W. Ł. were as follows. The left biceps activates as first, then the right biceps, muscle activation is connected with lifting the ball to a throw phase. In this phase the left biceps has the highest activation level. The left arm is dominant, so it should generate smaller bioelectric activity as the limb which is used more often and more technically perfect. The next phase, throw of the ball, occurs with the largest share of the right triceps, which has activation by 1800μV higher than the opposite side, but it activates later than the left one. Higher activation results most likely from the fact that this limb is dominant during the throw. In this phase the limbs are not equally loaded. Muscles of the dominant limb have also longer activation period.

Taking into account the same muscles of both limbs, the players were tested with respect to the most frequent passing technique in basketball, which is a two hand chest pass. The most accurate passing player was a right-handed one of initials C. K. His passing move was started by both biceps, their task was to pull the ball to the chest. Both muscles ended their work simultaneously at the moment, when arms started to fall down after passing. Antagonist muscles also had simultaneous beginning of their activation, but it occurred later. In addition, the right arm triceps reached slightly higher maximum. Like in the previous case, both muscles ended their work simultaneously, when arms returned to the body. It can also be noted, that during the analysis of larger number of passes, EMG in all tested muscles is very variable. During testing of thirty passes to the target, there was no rule which arm reached larger activation, once it was right arm, once the left arm. It was observed, however, that the right arm triceps reached much higher level of activation that the left one, passes were more accurate.

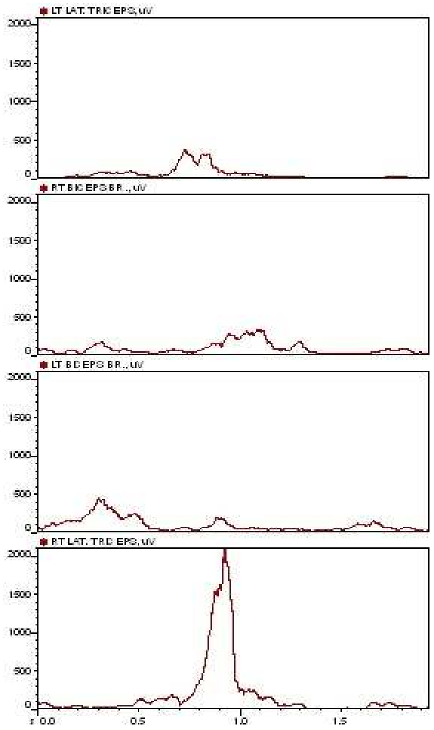

Fig. 5. "Smoothed" EMG record of both limbs muscles – player's initials: W.Ł.

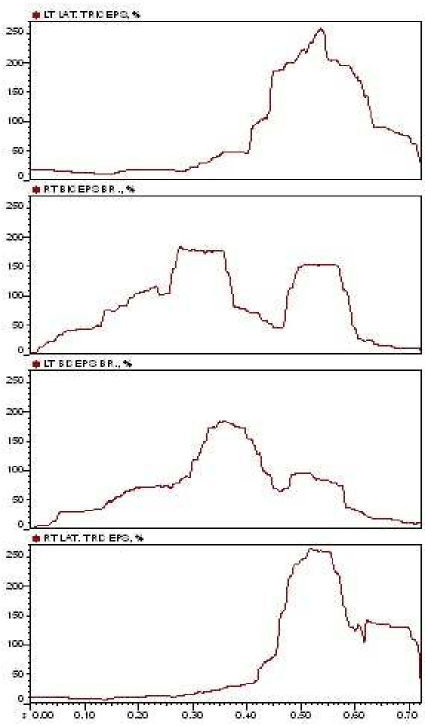

Fig. 6. "Smoothed" EMG record of both limbs muscles – player's initials: C.K.

DISCUSSION

Performed testing allowed to analyze the bioelectric activity level of arm muscles during shots and passes. They demonstrated that the average bioelectric activity of arm muscles was higher in case of less experienced players. It can confirm research made by Borysiuk (2006), Salvatore et al (2008), who stated, that the advance level has influence on the activation, the higher it is the smaller activation.

The objective of testing, among others, was the two hand chest pass, where the target was determined and the distance to it. Due to the fact that this move technique consists in a symmetric move of arms, the task should be performed with similar bioelectric tension in muscles of the right and left side of the body. During testing different average results of bioelectric tension of muscles were obtained, which may indicate the reserves with respect to symmetric preparation of basketball players. In addition, the difference between tension of the same muscles on both sides of the body is visible in groups being tested. In the novice group, differences in musculus triceps brachii were 57.011 μV, and in musculus biceps brachii 39.445 μV. Players from experienced group showed smaller differences in muscle activation, i.e. musculs triceps brachii 23.554 μV, musculus biceps brachii 5,034 μV. Smaller disproportions were observed in a more advanced group, which may indicate the proper focus of practice, which develops muscles of both sides of the body to a similar extent.

Evaluation of EMG curve allowed to observe a pattern of muscle activation during the free throw and chest passes. When analyzing the throw, musculus biceps brachii of the left arm activates as first, then the visible activation occurs in the left arm. At this moment, the movement of the ball above the player's head begins. Activity of triceps brachii muscles occurs at the end of the previous move, and the left arm muscle activates as first. Activation of triceps brachii muscles is the effect of arm straightening start in the elbow joint. Earlier activation of the left side is most likely the result of the support function that this arm provides. Furthermore, it can also result from the fact that this arm is always closer to motion direction, during the ball lifting over the head, as well as straightening of arms in elbow joints. Taking into account the tested muscles of arms, the pass starts from simultaneous activation of biceps brachii muscles, in order to take a swing. Triceps brachii muscles also activate in the same time, and their activation resulted from giving speed to the ball through arm straightening in elbow joints.

Tests also verified hypotheses that skills and move duration will be on a higher level in case of players, who are at the focused stage of training.

CONCLUSIONS:

1. Skills in shots and passes are better on the focused stage of training.
2. Players more advanced in practice show smaller average EMG bioelectric activity during the move, thus their activities are more economic.
3. In asymmetric shots, more experienced players showed higher activation of the dominant arm, and in symmetric shots beginners demonstrated higher activation of muscles.
4. Muscles of the left limb showed higher statistic validity for the benefit of more experienced players.
5. EMG activation signal is mostly dependent on the work which it makes, it generates higher tension if the work is harder.
6. Duration of the motor activity, from the beginning of muscle activation until the target is reached, was shorter in case of advanced players.

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