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# ACTIVITY OF SHOULDER MUSCLES DURING SHOTS OF DIFFERENT DIFFICULTY LEVEL IN MORE AND LESS SKILLED NOVUS PLAYERS

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## ABSTRACT

The aim of the present study was to compare the activation of the shoulder muscles in more and less skilled novus players during shots of different difficulty level. Nineteen competitive novus players (9 more skilled and 10 less skilled) were recruited to examine bioelectrical activity of the shoulder muscles (trapezius, deltoid lateral and posterior muscles) during a striking accuracy task. Participants performed 3 series, each consisted of 10 novus shots – 10 penalties, 10 cut and 10 rebound shots. Surface EMG (sEMG) amplitude of posterior and lateral deltoid and trapezius muscle of the subjects' dominant side was measured during the shot and compared between successful versus unsuccessful shots in more skilled and less skilled players. Unsuccessful penalties and rebound strokes compared to successful ones in more and less skilled players, and unsuccessful cut shots compared to successful ones in more skilled players are characterized by higher activity in trapezius muscle. Higher activity of trapezius muscle is a characteristic feature of less skilled players' novus shots. During successful penalties, cut and rebound shots the sEMG amplitude of trapezius muscle in more skilled players was significantly lower (34%; $p<0.05$; 19%; $p<0.001$ and 60%; $p<0.01$, respectively) than in less skilled players.

***Key words:*** *cuesports, electromyography, bioelectrical activity, expert-novice differences*

## INTRODUCTION

In cuesports it is considered quite natural that the players with higher qualification exceed their less skilled opponents in the accuracy of shots. Proof to that widespread point of view can also be obtained from previous studies [7, 11]. It has been verified that more accurate shots are not the result of better vision – visual acuity of experts is no better than that of novices and intermediate players [1]. The fact that experts are better decision makers, can recall, recognise, and assess various sophisticated situations more easily and plan ahead more successfully [1] does not help them either when the players have to perform just a simple shot. A quite frequent mistake of novices is a too heavy stroke [9]. Wall and Crimi [10] considered the most difficult in committing a shot the choice of stroke force. Analysis of impact velocity measures showed that cue velocity of expert and novice snooker players differed significantly [7]. Experts demonstrated more consistent velocity of the cue from shot to shot compared to novices. Besides that, vertical impact velocity of the stroke which ideally should be zero was significantly lower in experts than in novices. The authors explained their result with an opinion that the experts had acquired necessary movement patterns and also with the improvement of handling the cue, minimal deflection of it during the stroke [7]. Taking into consideration prior findings we can assume that carrying out a successful shot depends greatly on the skill of handling the cue and there is a great probability that this is conditioned by one's muscle recruitment.

Electromyographic (EMG) data of skeletal muscles' activation and its differences when comparing experts and novices has been studied in several sports like archery [4], cycling [3], badminton [8], tennis [5], and golf [2]. In a golf expert-novice comparison no significant differences were found between the EMG records of the two groups [2]. Even more – there was considerable inter-subject variation amongst the expert subjects. Nevertheless, experts' individual muscle activation patterns were remarkably consistent from trial to trial. The authors concluded that there were different combinations of muscle action that could be used to produce similar kinematics [2]. However, differences in EMG data have been found not only between athletes of different qualification levels [3, 4, 5, 6, 8] but also between successful and unsuccessful performance [6, 8]. Chapman et al. [3] explained the differences between the EMG data of experienced and novice cyclists with the skilled and masterful movement of highly qualified athletes and considered probable that it was the result of neuromuscular adaptation acquired during long-time workout. To the best of our knowledge, there has been no experimentation of how muscle recruitment helps to succeed striking in cuesports. The aim of this study was to compare the bioelectrical activity of trapezius, posterior deltoid and lateral deltoid muscles during shots of different difficulty level in more and less skilled novus players.

## MATERIALS AND METHODS

### Subjects

Nineteen novus players (5 female and 14 male) participated in the study. The subjects were distributed into two groups according to their year 2010 competition results: 1) highly skilled (2 female and 7 male; mean age 47.89 years, range 24–63 years) and 2) less skilled (3 female and 7 male; mean age 35.5 years, range 13–67 years) novus players. The members of the highly skilled group have frequently shown high results in international competitions, 3 of them (2 female and 1 male) have been European champions. The average playing experience of more skilled players was 28.3 years (ranging 13–43 years) and of less skilled players 7.1 years (ranging 2–28 years).

### Measures

***Measurement of muscle bioelectrical activity***

Surface EMG (sEMG) was used to measure the bioelectrical activity of trapezius and deltoid muscles during different novus shots. sEMG activity of the muscle activation was recorded by 16-channel electromyograph ME6000 Mega Electronics and software Megawin (Finland). Bipolar sEMG electrodes (Noraxon, USA) were placed on the following muscles on subjects' dominant body side: posterior and lateral deltoid (4–5 cm below acromion) and trapezius muscle (middistance between cervical vertebra $C_7$ and acromion). In order to prevent shifting, wires between the electrodes and the amplifier were fixed to the subjects' body with a tape. Bioelectrical (sEMG) activity (μV) of the shoulder muscles was registered during unsuccessful (Figure 1A, 1C) and successful (Figure 1B, 1D) strokes in less and more skilled novus players. Peak amplitude during the shot was measured.

***Performance outcome estimation***

The participants had to commit 3 series, each consisting of 10 novus shots – 10 penalties, 10 cut and 10 rebound shots. The placement of the discs (only one disc on the board at a time) was the same within one series and for all participants. The subjects were asked to perform as well as they could and to pocket as many discs as possible. During the strokes the performance outcome (successful eg a pocketed disc / unsuccessful eg a missed shot) was registered for each attempt.

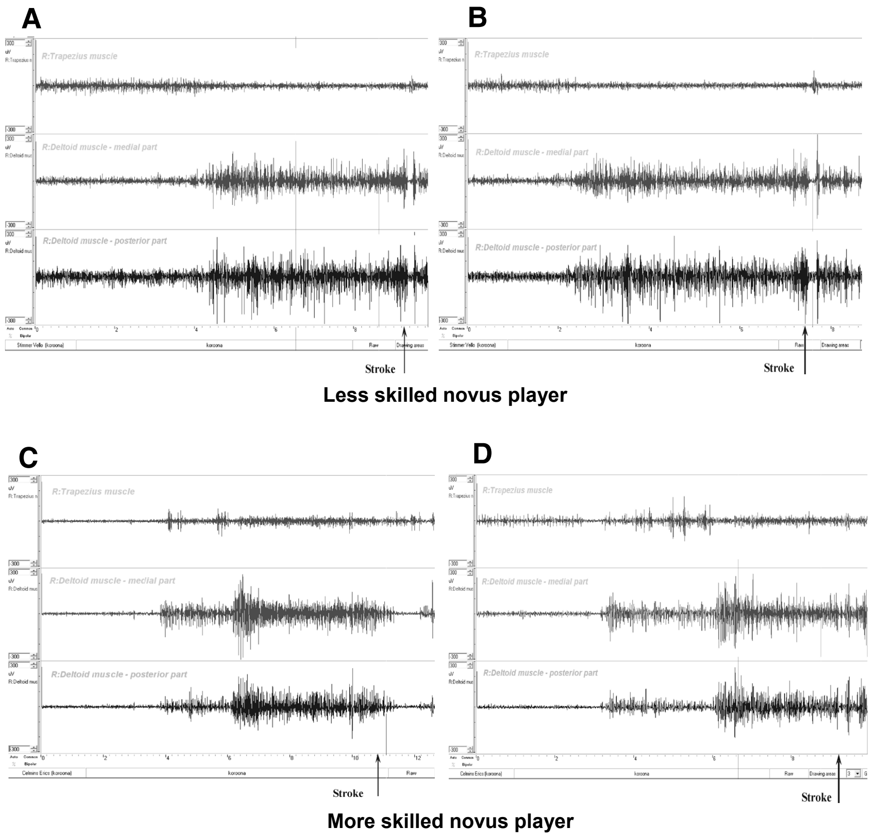


**Figure 1.** Bioelectrical (sEMG) activity (μV) of the shoulder muscles during unsuccessful (A, C) and successful (B, D) penalty shot in less and more skilled novus players. Vertical line–moment of stroke, before it–stroke preparation phase; after it–stroke phase and relaxation phase. More skilled player in stroke preparation phase have initially more relaxed shoulder muscles and specific pre-stroke muscles activation as well as post-stroke muscles relaxation. Trapezius muscle–upperline, lateral deltoid muscle–middle line and posterior deltoid–lower line

### *Experimental design*

The study was carried out at the Laboratory of Kinesiology and Biomechanics of the University of Tartu in 2011. For the experiment internationally accepted novus board with a playfield size 100 x 100 cm and pockets with a diameter 100 mm were used. Players used their own cues and strikers. The strikers were weighed in order to ascertain their weight corresponds to the international novus regulations. At first sEMG electrodes were fixed to subjects' dominant body side on shoulder muscles: posterior and lateral deltoid and trapezius muscles. Then the subjects were thoroughly explained the shots they had to commit. Before carrying out the test each subject had 15 minutes for practising. During the shots sEMG parameters were measured.

### Statistical analysis

Data are expressed by means and standard error of mean (±SE). The significance of the differences between the two groups of subjects and between successful versus unsuccessful shots was analyzed by the unpaired Student t-test. A level of $p<0.05$ was selected to indicate statistical significance.

## RESULTS

In more skilled players the peak EMG amplitude of trapezius muscle ($p<0.05$), lateral deltoid ($p<0.01$) and posterior deltoid muscles ($p<0.05$) during successful performing of penalties was significantly lower (34%, 61%, and 61%, respectively) than in less skilled players (Figure 2A). Analogous difference between highly skilled and less skilled players was observed in trapezius ($p<0.01$) and posterior deltoid ($p<0.001$) muscles during unsuccessful shots.

More skilled players had lower sEMG peak amplitude during successful penalty shot as compared to unsuccessful penalties in trapezius ($p<0.01$), lateral deltoid ($p<0.001$), and posterior deltoid ($p<0.001$) muscles – 40%, 91%, and 34% respectively. Similar differences in sEMG peak amplitude values were found in less skilled players – its values during successful shots were 16% in trapezius ($p<0.001$) and 56% in posterior deltoid ($p<0.001$) lower than at unsuccessful shots.

During successful cut shots the sEMG amplitude of trapezius muscle in more skilled players was significantly lower (19%; $p<0.001$), but the amplitude of lateral and posterior deltoid muscles was higher (27%; $p<0.05$ and 39%; $p<0.001$, respectively) than in less skilled players (Figure 2B). Also, a significant increase of the sEMG amplitude of trapezius muscle during unsuccessful cut shots in more skilled players' successful and unsuccessful shots was found (188%; $p<0.01$) – it was higher as compared with successful cut shots.

The analysis of sEMG data measured during the rebound stroke revealed that the sEMG amplitude values in trapezius muscle of less skilled players were significantly higher than the values of more skilled players during both successful and unsuccessful shots (60%; $p<0.01$ and 115%; $p<0.001$, respectively) (Figure 2C). Higher values of sEMG amplitude were also observed in unsuccessful compared to successful rebound shots in more skilled players' trapezius (97%; p<0.01), lateral deltoid (32%; p<0.05) and posterior deltoid (56%; p<0.05) muscles, as well as in less skilled players' trapezius (166%; p<0.001) and lateral deltoid (24%; p<0.05) muscle.

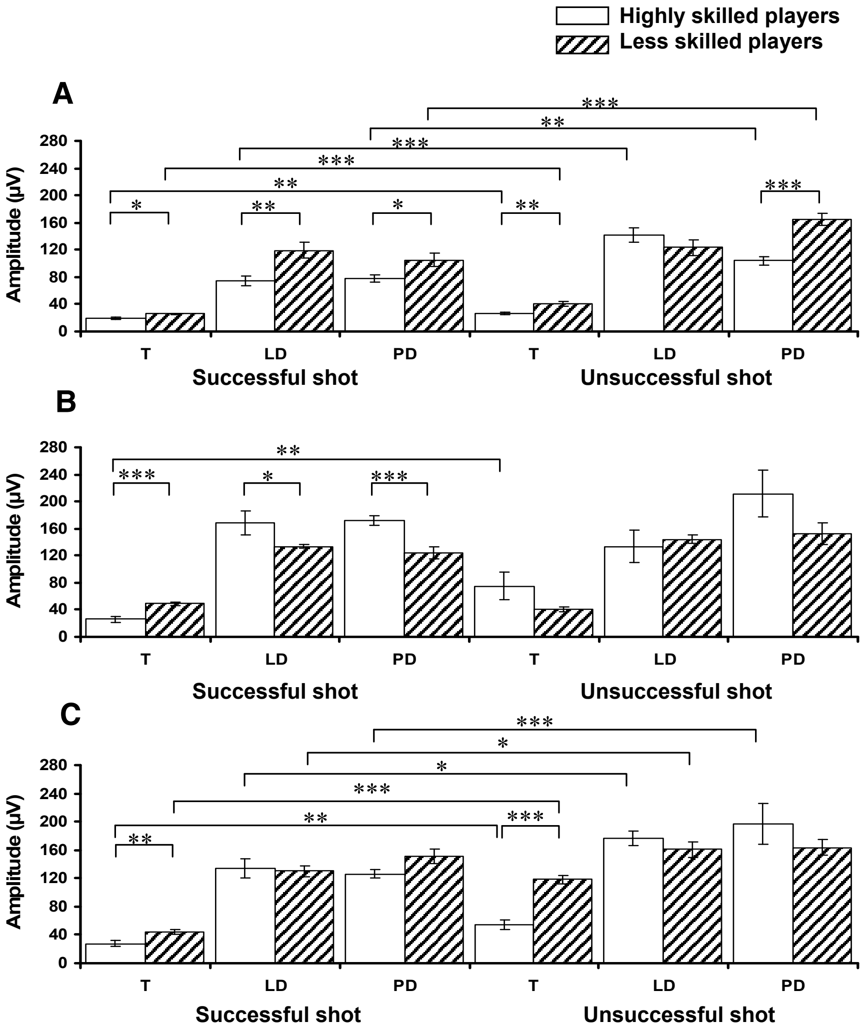


**Figure 2.** Peak amplitude of bioelectrical activity of the shoulder muscles in more and less skilled novus players during different kinds of successful and unsuccessful shots: A – penalty, B – cut shot, C – rebound shot, T – trapezius muscle, LD – lateral deltoid muscle, PD – posterior deltoid muscle (mean±SE). *p<0.05; **p<0.01; ***p<0.001

## DISCUSSION

The present study investigated differences in bioelectrical activity of shoulder muscles during different kind of novus shots in more and less skilled athletes. The main finding of the study was that unsuccessful penalties and rebound strokes in more and less skilled novus players and cut shots in more skilled players are characterized by higher activity in trapezius muscle. The sEMG amplitude of trapezius muscle during successful penalties, cut and rebound shots in more skilled players was 40% ($p<0.01$), 188% ($p<0.01$), and 97% ($p<0.01$), respectively, lower than at unsuccessful shots. Besides that, we can say that the higher activity of trapezius muscle is a characteristic feature of less skilled players' novus shots. During successful penalties, cut and rebound shots the sEMG amplitude of trapezius muscle in more skilled players was significantly lower (34%; $p<0.05$; 19%; $p<0.001$ and 60%; $p<0.01$, respectively) than in less skilled players.

More accurate shot of experts and the ability of highly skilled players to direct the cue in the desired direction [7, 11] could be connected with efficient muscle recruitment acquired during long-time practice. Too high activity of trapezius, posterior deltoid and lateral deltoid muscles could be one of the reasons for the failure of a shot. Differences in sEMG values of more skilled and less skilled novus players refer to the fact that players with higher qualification have acquired a skill to use trapezius and deltoid muscles with a different activation pattern than the less skilled players do. The results of the current study support the assumption that differences in EMG activity values between experts and athletes with lower qualification are the result of neuromuscular adaptation acquired during long-time workout [3].

Expert-novice differences have been a popular topic for quite long time. Muscle activation differences between more and less qualified athletes have been studied [2, 3, 4, 5, 8] but still not much is known. Present study helped to get an insight into shoulder muscle activation pattern during a stroke in cuesports. Better understanding of how athletes with higher qualification differ from their less skilled opponents helps to find ways for more effective training.

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