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COMPARISON OF LUMBAR AND ABDOMINAL MUSCLES ACTIVATION PATTERN IN TWO DIFFERENT SKILL LEVEL GOLF PLAYERS: AN EMG ANALYSIS

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Abstract

Introduction: Golf is a popular sport and golf swing is a complex movement which requires a coordinated sequence of muscle activity. Two types of skill level exists i.e. “High” and “Low”. The more skilled golfer displays less variability in the golf swing. A relationship exists between variability of muscle activity and skill level, which is important when considering their effects on the lower back.

Aim of the study: The present study compared muscle activation amplitudes in the trunk region of two different skill level golfers during golf swing.

Materials and Methods: 22 right handed male golfers (21.5 years ±3.4). 11 high skilled (0-8 handicap) and 11 less skilled (10-18 handicap) were instructed to perform golf swing and surface EMG activity was recorded from external oblique (E.O.), internal oblique (I.O.), and erector spinae (E.S.) muscles of both sides.

Results: Results showed that when both groups performed golf swing the high skilled level players showed lower EMG activity of left E.S. and right E.O. during all the phases of golf swing, but right E.S. showed decreased activity only during backswing phase. All the other muscles i.e. left E.O. and both side I.O. showed higher activity in high skill level players.

Conclusions: The above findings showed that muscle activity does not consistently show any uniform patterns during the golf swing, thus the results were not irrefutable. EMG evidence proposes that the there is a lack of subjective and objective relationship between skill level and EMG activity of lumbar and abdominal muscles as determined by SEMG.

Key words: *EMG, high skill, low skill, abdominal obliques, erector spinae*

Introduction

Golf is a popular sport and the basic rules of the game are the same regardless of age, sex, or skill level (1). According to Batt (2) Golf cannot be considered as a particularly demanding sport either aerobically or anaerobically; however to play well requires considerable skill and practice. Golf swing is a complex movement which requires a coordinated sequence and considerable amount of muscle activity to efficiently transfer the power generated by the golf swing (3).

Research has also found that most common injury mechanism was during the golf swing and low back pain has been identified as most common musculoskeletal problem affecting both amateur and professional golfers (4). The amateur golfer is more likely to have an aberrant swing pattern that could predispose to injury at a rate potentially greater than the professional golfer and low back pain has been identified as the most common musculoskeletal problem affecting both amateur and professional golfers (4). A study of 30 beginning golfers demonstrated a high prevalence of weight shift to the incorrect foot at the top of the back swing (5). As many injuries were related to the golf swing, asymmetrical nature of the golf swing, skill level and the larger forces associated with the swing may be again a predisposing factor in golf swing related injury (6).

A relationship between myoelectric activity of trunk muscles and golf swing was also assessed by different researchers (1,7). Many different muscle groups contribute to initiation and completion of golf swing, the trunk muscles i.e. lumbar erector spinae and abdominal obliques are known to contribute considerably to the generation of power and stability during different phases of golf swing. Using surface EMG Pink et al. (1) and Watkins et al (7) found the activity of these muscles during different phases of golf swing.

The more skilled golfer displays less variability in the golf swing and a relationship exists between variability of muscle activity, swing time and skill level (8). Higher handicap players tend to generate more power using their arms with relatively less contribution from their trunk. Similarly, they produce greater spinal torque and lateral bending forces during the golf swing (2). Abernethy et al. (9) also reported the same results for the expert and the novice group. Expert golfers had a significantly more consistent pattern of shoulder and wrist movements and temporal patterns of the chip shots than the novice players. A significantly greater variability in joint kinematics and muscle activity between trials for novice than experts golfers appeared to contribute significantly to the novice golfer’s reduced chipping accuracy and inability to specify the required force.

Hosea et al. (10) found that the surface EMG examination of lumbar paraspinal muscles revealed that professional demonstrated reduced peak lateral bending and shear loads during forward swing phase with more efficient load production through out a full range of motion, they also showed to generate greater club head acceleration at impact, while producing lower spinal loads and lower EMG activity (2).

The overall myoelectric activity of the amateurs (less skilled) while swinging a golf club reached nearly 90% of their peak muscle activity compared with 80% for the professionals. The professionals demonstrated a discrete on-and-off muscle-firing pattern consistent with a grooved swing, whereas the amateurs lacked the same precision (10); however the muscles examined for this study were not specified.

Less skilled and highly skilled golfers thus have differences in the magnitude of their spinal loading and muscle activity during the swing. The less skilled have poor swing mechanics resulting in larger spinal loads with corresponding higher myoelectric activity.

Although the above literature provides valuable amount of information on golf kinetics, kinematics, muscle activity during golf swing and injury patterns but none has specifically compared myoelectric activity of lumbar and abdominal muscles in different skill level golfers. Documentation of myoelectric activity in these muscle during two different skill levels allow a better understanding of the stresses associated with golf swing and skill level. It could lead to technique modifications that would minimize low back stress and injury risk.

The aim of present study was to investigate if there was a correlation between skill levels of golfers and muscle activation pattern using surface EMG.

Materials and Methods

Study Design: Different subject experimental design was used for this study.

Participants: Twenty two only right handed male golfers- 11 high skilled (0-8 handicap) and 11 less skilled (10-18 handicap) belonging to Panthers Golf Club Amritsar volunteered to participate in this study. Left handed players were excluded from the study to standardize the data. All subjects gave informed consent before participating in this study. All were free of any orthopedic or neurological disorders. The average age was 21.5 years (±3.4) with a range of 15 to 27 years.

Technique: The golf swing was divided into the following four points in time and a webcam was used for defining these points:

1. Address: The instant before the first movement of the club head away from the ball.
2. Top of Backswing: The instant at which the club head reached its most lateral position, before changing direction.
3. Impact: The instant after which the ball had left the tee. At this point, the club head was in a position similar to that which it was in at the address.
4. End of Follow-through: The instant when the club head came to rest behind the golfer.

From these points the backswing was defined as the time between the address and the top of backswing, the downswing was as the time between the top of backswing and impact, the follow-through as the time between impact and the end of follow-through and total swing as the sum of backswing, downswing, impact and follow-through.

General Procedure: Each golfer was asked to warm up and take the several practice swings before the study so that they prepare for maximal effort shot with a 5 iron. Subsequently, golfers were asked to hit 10 maximal efforts shots. As EMG used in experiment is a 4 channel one the first 5 shots were taken using E.S. and I.O. muscles of both sides. Similarly, remaining 5 shots were taken using E.O. and I.O. muscles of both sides. This set up is used to look for the reproducibility pattern of golf swing and the data were recorded only when the I.O. EMG activity showed reproducibility. These shots were hit with 5 iron while video and EMG data were recorded simultaneously.

Instrumentation: Apparatus used for surface EMG recording was NORAXON 4 channel EMG, USA manufactures: Myosystem 1200. EMG signals were amplified by Driver Linx (input impedence =10 milliohm A/D converter with ±5V input range). Following settings were used: bandwidth =10-500 Hz, input impedance =10mΩ, CMRR = 110 dB, maximum input voltage = ±5V, sampling rate = 1000 Hz, gain =1000, RMS window = 100ms.

EMG data recording: Each subject's skin was prepared for EMG electrode placement by shaving, abrading the skin with fine emery paper, and than cleaning the area thoroughly with an alcohol swab. Pairs of Ag-AgCl surface EMG electrodes (8 mm active diameter) were attached to skin. The inter electrode distance was kept constant at 20 mm apart along the expected muscle fiber direction of the external oblique (E.O.) (15 cm lateral to umbilicus at transverse level of umbilicus), internal oblique (I.O.) (below external oblique and just superior to the inguinal ligament) and erector spinae (E.S.) (6 cm lateral to L_2). A ground electrode was placed over the left anterior superior iliac spine. Video data were collected simultaneously using a webcam (Logitech-0.5 mega pixel) which was connected to EMG machine to synchronize with EMG data during different phases of the golf swing.

EMG normalizing procedure: Before the golf swing trials, EMG data of above muscles were collected during maximal voluntary isometric contractions (MVIC) in order to normalize the EMG data during the swing. Subjects were asked to perform MVIC for each concerned muscle as described by Daniels and Worthingham's (11). EMG data was collected for 10 seconds (3 repetitions) and the maximum activity for 1 second was taken as MVIC. All EMG activity reported here is expressed as %MVIC.

Statistical Analysis: All the data were analyzed using related (paired) 't' test to determine significant differences that existed between two types of swings. The p-value was considered significant when it was found to be less than the usual level of 0.05. The Statistical analyses were performed using SPSS 14.0.

Results

Because the golfers all played right handed, the backswing phase represents a clockwise rotation of each subject's torso. The large standard deviation among the golfers in muscle activity recorded during each phase of the golf swing is a phenomenon commonly encountered in EMG studies. This is why only reproducible trends in muscle activities during the phases of golf swing rather the absolute numbers were analyzed.

Erector Spinae Activity

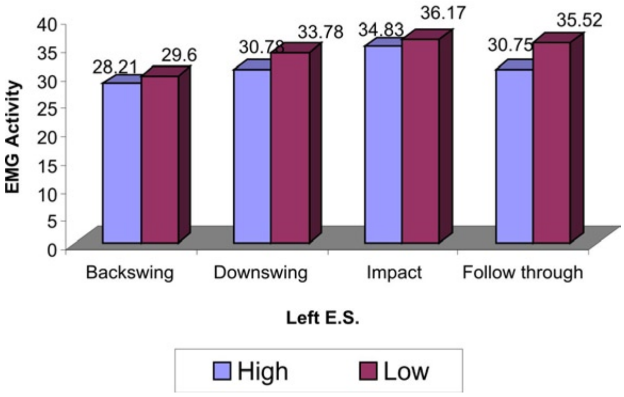

Fig. 1. *% MVIC activity of left E.S. in high skilled and low skilled players during various phases of golf swing*

Left E.S.: The left erector spinae muscle exhibited EMG activity below 30% MVIC (29.6% in low and 28.21% in high skill) during backswing. Activity of E.S. in high skill players showed 30.78% and low skill players showed 33.78% MVIC during down swing phase. In impact phase activity of the muscle continuously increased in both low and high skill level players to 36.17% and 34.83% respectively. While in follow-through phase high skill level players recorded 30.75% and 35.52% MVIC for low skill level players (Fig. 1).

Right E.S.: Muscle exhibited higher activity in low skill players (29.11%) and lower in high skill players (28.97%). During downswing phase activity was 35.15% and 29.79% MVIC and in impact phase it showed 36.37% and 31.89% for high and low skill level players respectively. In follow-through low skill players showed 32.74% MVIC and 34% MVIC was shown by high skill level players (Fig. 2).

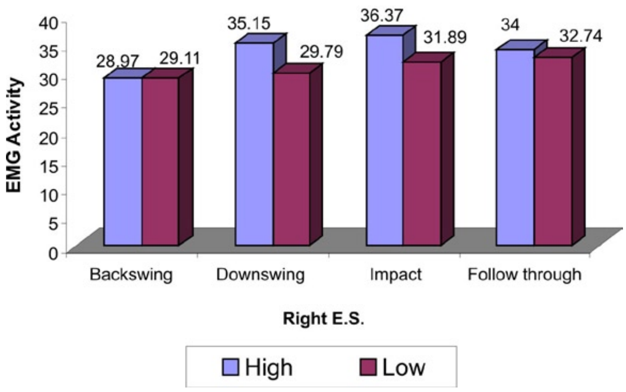

Fig. 2. *% MVIC activity right E.S. in high skilled and low skilled players during various phases of golf swing*

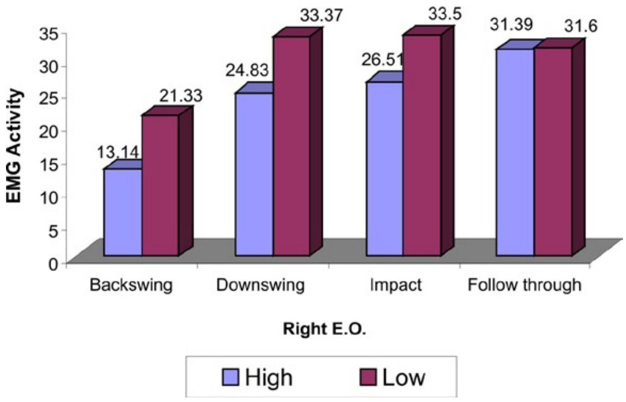

Fig. 3. *% MVIC activity right E.O. in high skilled and low skilled players during various phases of golf swing*

External Oblique Muscles

Right E.O.: The right external oblique muscle demonstrated muscle activity of 13.14% and 21.33% MVIC in the high and low skill players respectively, during backswing. The activity increased to 24.83% and 33.37% MVIC for the high and low skill level players respectively during downswing. It remained high in both skill level players during impact phase 26.51% and 33.5% in high and low skill players respectively. During follow-through, it exhibited 31.39% in the high and 31.6% in the low skill level players (Fig. 3).

Left E.O.: During backswing it demonstrated 22.36% and 16.58% MVIC activity in high skill and low skill level players respectively. The activity during downswing increased to 24.27% and 23.8% for the high and low skill players respectively. It remained high during impact phase where it showed 27.39% in the high and 23.87% in the low skill players. In follow-through phase, it exhibited 29.17% and 26.16% MVIC in the high and low skill level players respectively (Fig. 4).

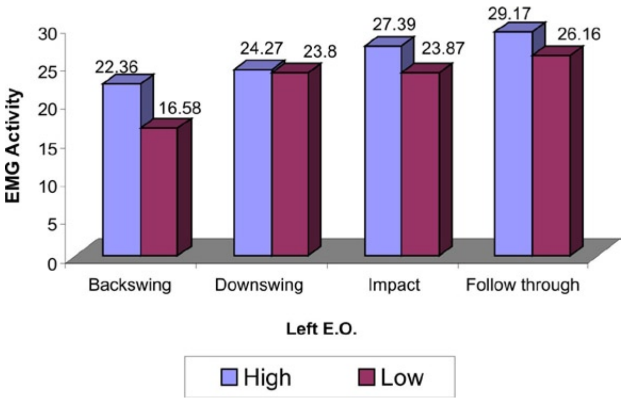

Fig. 4. *% MVIC activity left E.O. in high skilled and low skilled players during various phases of golf swing*

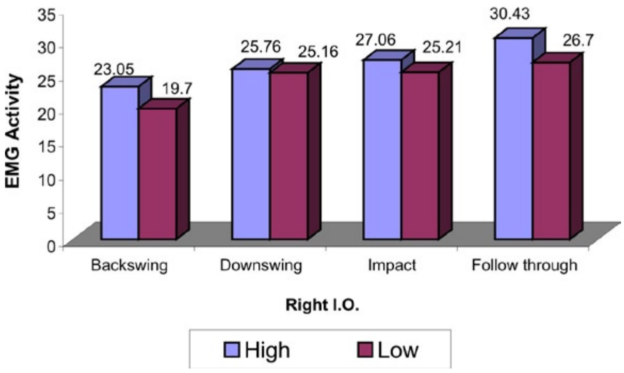

Fig. 5. *% MVIC activity right I.O. in high skilled and low skilled players during various phases of golf swing*

Internal Oblique Muscles

As explained in the general procedure of materials and methods section, the internal oblique muscle was taken during both types of recordings i.e. one when E.S. muscle was used and one when E.O. muscle was used. Only the higher values of I.O. were taken for data analysis. This method was adopted to look for reproducibility of the golf swings and we found that activity of I.O. was approximately same in both methods.

Right I.O.: The right internal oblique muscle demonstrated muscle activity of 23.05% and 19.7% MVIC in the high and low skill players respectively, during backswing. The activity increased to 25.76% and 25.16% MVIC for the high and low skill level players respectively during downswing. It remained high in both skill players during impact phase 27.06% and 25.21% in high and low skill players respectively. During follow-through, it exhibited 30.43% in the high and 26.7% in the low skill level players respectively (Fig. 5).

Left I.O.: During backswing it demonstrated 21.53% and 18.92% MVIC activity in high and low skill players respectively. The activity during downswing increased to 33.32% and 30.6% for the high and low skill players respectively. It remained high during impact phase in high skill players where it showed 36.4% and 24.77% in the low skill players. In follow-through phase, it exhibited 35.05% and 31.23% MVIC in the high and low skill level players respectively (Fig. 6).

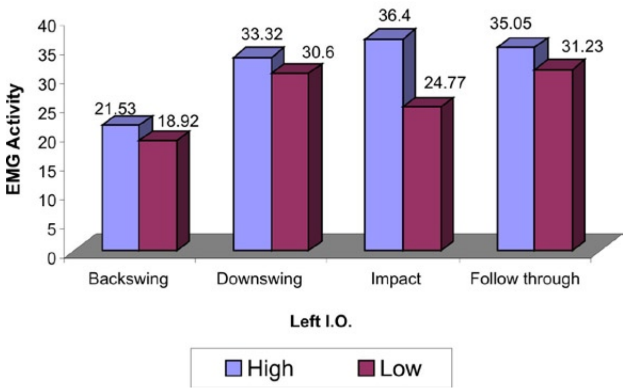

Fig. 6. *% MVIC activity left I.O. in high skilled and low skilled players during various phases of golf swing*

Discussion

Golf is popular and fast emerging sport, which is played by all age groups and gender across all the socio-economic groups. The surge in golf popularity and people associated with it leads to greater reporting of injuries associated with golf, thus refuting the common notion that golf is a novel game with fewer chances of injuries.

Various studies have suggested different means/mechanism of golf injuries among professional and amateur players for e.g. poor swing mechanics, hitting the ground and overuse syndromes (12).

The present study aims at finding EMG evidences of such above mentioned notions. The result of this study on the activation of trunk muscles during the golf swing in two different skill level players gives the sport medicine practitioner an element on the specificity, thus helping him in understanding the technicalities of the popular sport golf.

In the current study, comparison was made between High and Low skill level players for selected lumbar and abdominal muscles. Though studies in the past (13) have determined the injury patterns during golf swing, golf kinetics and kinematics and also muscle activation pattern (3) and motor recruitment during golf swing no reference of which skill level player was studied has been made.

The backswing phase is actually a coiling or loading of the body that enhances the distance traveled in forward arc of motion. It is characterized by right axial rotation of the body. The distance traveled contributes to both club head velocity and the kinetic energy that will later be passed on the ball. The top of the backswing may also stretch the trunk muscles, thus facilitating their action in forward swing. The left E.O. and right I.O. contracts to aid this trunk rotation in the backswing. Muscle activities of left

E.O. and both sides I.O. during back swing found to be lower in less skilled players as compared to high skilled players (Fig. 4, 5 & 6), though not statistically significant (p>0.05). On comparing muscle activity of E.S. muscle in our study we found that it was higher (though not statistically significant) for both side E.S. and right E.O. in less skilled players than high skilled players (Fig. 1, 2 ,3).

The downswing is often reported as being made up of two arbitrary components, the forward swing (the early down swing) and the acceleration phase, which begins when the club is parallel to the ground. The early phase of downswing (forward swing) is characterized by the return of the body back to the ball in preparation to hit it. Throughout this phase the gravity and rotational forces were resisted to maintain body position and since the subjects were falling forward while rotating from the right side to the left side, it is logical that right E.S. were more involved in countering gravity. It was evidenced by the enhanced EMG activity in the right side as opposed to the left side. This right side E.S. activity was found to be more in high skill players than the low skill players and vice versa for the left side E.S. muscle (Fig.1,2). Electrical activities of E.O. and I.O. in high skill players were found to be high (except in right side E.O.) in comparison to less skill players (Fig. 3, 4, 5, 6).

Although the impact phase of the golf swing is a specific point in time, and instantaneous muscle activity is difficult to evaluate, there is fairly consistent level of EMG activity bilaterally in E.S., E.O. and I.O. muscles. As discussed above, it has been shown that the oblique muscles are more responsible for the rotation (14) that continues to occur and that the oblique muscles play a role bilaterally (15). Left side of Obliques was found to be more active in high skilled players than the right side whereas this was not the same in the case of low skilled level players (Fig. 3, 4, 5, 6). This shows continuous rotation of the trunk back to the ball from the right rotated (backswing) position. Also, since motion is continuously moving centrally (i.e. club is closer to, and in line with, the body), both sides of E.S. muscle are now needed to counteract gravitational forces. Hence, very analogous values of EMG were reported (Fig. 1, 2).

Thus though differences in the levels of muscle activities of E.S., E.O. and I.O. were there, in the two levels of skills we compared in our study. They were minimal and were found to be not significant statistically (p>0.05) to be considered convincing (Fig. 1, 2, 3, 4, 5, 6). This may be due to highly individualistic nature of golf swing and also various factors such as age, height, weight and flexibility of individuals (16).

Once the ball had been hit, the trunk continued to rotate in follow-through as the motion was decelerated and the energy dissipated, a number of muscles are eccentrically loaded to aid the deceleration of body and golf club. This is particularly true of the trunk muscles as at this point, posture and control were still needed and the trunk served to decelerate the rotation, as opposed to the impact phase. In this phase E.O. and I.O. activity increased faintly and noticeable but insignificant (p>0.05) change were reported which may be due to continuous axial rotation of trunk. This show stability and mobility function of oblique muscles (1,17). Activity in left E.O. and both sides I.O. muscles in low skilled players continued to be lower than the high skilled players (Fig. 4, 5, 6). The E.S. muscle activity during follow-through phase was still noteworthy, but the intensity was lower in both groups with left side showing more activity than right side in low skilled players and a vice versa for the opposite group (Fig.1, 2).

Prior researches found that the most noticeable cinematographic differences between professionals and amateurs were in the degree of trunk rotation (1). In addition, these researchers reported that the older and less skilled players had less than half of the trunk rotation of younger and more skilled players (1). Therefore the players with less trunk rotation may use muscular substitution patterns to compensate for the decreased rotation (1), which is evident by the results of the present study.

From the current study it can be observed that when both groups performed golf swing the high skilled level players showed lower EMG activity of left E.S. and right E.O. during all the phases of golf swing (Fig. 1, 3) whereas right E.S. showed decreased activity in high skill level players only during backswing phase (Fig. 2). All the other muscles i.e. left E.O. and both side I.O. showed higher activity in high skill level players when these activities were compared with less skill level players (Fig. 4, 5, 6). Also from the above findings we can see that muscle activity does not consistently show any uniform patterns during the golf swing; thus the results were not irrefutable.

The inclusion criteria used in our study was a minimum of six months of play. All the volunteers in this study had an average of one year of play. Some of then made it to the 0-8 handicap level (high skill) and the others were in the 10-18 handicap level (low skill). We believe that less than one year of participation is not sufficient for preferential neural activation of the muscles as detected by SEMG. Future studies may have more conclusive results if the period of play is taken into consideration, further golf players who have been playing the game for many years should be included. Another reason for these findings was this may be due to highly individualistic nature of golf swing; difference in population kinanthropometric variables such as somatotype, body fat percentage and other values such as age, height, weight and flexibility of individuals which should be taken into consideration (16).

Though most of the differences we observed in the two levels of skill were statistically insignificant we believe that this should not be neglected. EMG is a valid tool to study muscle activity and should be used to study the same. The sports clinician must recognize that differences in activation pattern of lumbar and abdominals muscles exists in two different skill level players i.e. high and low, so that key muscles may be trained for relevant group or movement involved in golf.

Conclusion

The EMG evidence from this study shows that one year of participation may not be sufficient to show preferential neural activation differences in muscles.

Thus the group of subjects we studied though differences in the EMG activity of E.S., E.O. and I.O. muscles were observed, they were not statistically significant. Thus, there were no significant differences were found in EMG activity of examined muscles in different skill level golfers.

Throughout the uncoiling of the golf swing (phases of down swing, impact and follow-through), the abdominal and erector spinae muscles revealed relatively high and constant activity which demonstrate the importance of the trunk muscles, as well as the potential for these muscles to fatigue. If the muscles are unconditioned, they could easily become fatigued, predisposing player to compensatory muscle firing and abnormal loading of joints and muscle, causing injury.

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