

Comparison of lumbar and abdominal muscle activation during two types of golf swing: An EMG analysis.

Comparación de la activación muscular abdominal y lumbar en la realización de dos tipos de swing en Golf: Un análisis electromiográfico

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Abstract

Golf is a popular sport and golf swing is a complex movement which requires a coordinated sequence of muscle activity. Two types of golf swing exists i.e. "Classical" and "Modern". Classical swing differs from modern swing in several respects, which are important when considering their effects on the lower back. The present study compared muscle activation amplitudes in the trunk region of golfers during two different types of golf swing. 22 golfers (21.5 years \pm 3.4) were instructed to perform modern and classical 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 showed muscle activity of right and left side of E.O. and I.O. to be lower in modern swing than classical swing (significant difference $p < 0.05$ in downswing and impact phase), whereas it is higher for both sides E.S. in modern swing. The E.S. muscle activity during follow-through phase was significantly higher ($p < 0.05$) in modern swing compared to classical swing. Significant differences in E.S. and other muscles activity suggest inappropriate recruitment of these muscles in golfers during the modern swing. EMG evidence proposes that the modern golf swing produces more extension forces in the lower back compared with the forces of classical swing.

Resumen

El Golf es un deporte popular y el swing en golf es un movimiento complejo que reclama una secuencia coordinada de movimientos. Existen dos tipos de swing: el clásico y el moderno. El Clásico se diferencia del Moderno en varios aspectos que son importantes cuando se consideran sus efectos en la parte inferior de la espalda. Este estudio comparó la amplitud de la activación muscular en el tronco de los golfistas al realizar los dos tipos de swing. Veintidos jugadores de golf (21.5 años \pm 3.4) fueron instruidos para realizar el swing moderno y clásico, tomándose la actividad muscular (actividad EMG) del Oblicuo Externo (O.E.), Oblicuo Interno (O.I), y Erector Spinae (E.S.) de ambos lados del cuerpo. Los resultados mostraron que la actividad muscular de los dos lados del cuerpo fue menor en el swing moderno que en el clásico, tanto en el O.E. y O.I. (diferencia significativa $p < 0.05$) en el downswing y en la fase de impacto, mientras que fue mayor, en ambos lados del cuerpo, en el E.S. en el swing moderno. La actividad del E.S. durante la fase de seguimiento (follow-through) fue significativamente mayor ($p < 0.05$) en el swing moderno en comparación con el clásico. Las diferencias significativas en la actividad muscular del E.S. y en otros grupos musculares, sugieren el reclutamiento inapropiado de estos músculos en los jugadores de golf. La actividad electromiográfica (EMG) evidenció que el swing moderno produce una mayor extensión de las fuerzas en la parte inferior de la espalda, en comparación con las fuerzas que produce el swing clásico.

Key words: EMG; modern swing; classical swing; abdominal obliques; erector spinae

Palabras clave: EMG; swing moderno; swing clásico; abdominales oblicuos; erector spinae

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Introduction

Golf is a popular sport and the basic rules of the game are the same regardless of age, sex, or skill level (Pink et al. 1993). According to (Batt, 1993) 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 (McHardy et al. 2005).

There are two types of golf swing which exists that is “Classical” and “Modern” golf swing. Classical swing differs from the “modern” swing in several respects, which are important when considering their effects on the lower back (Hosea et al. 1996).

The classic technique which is predominantly used in earlier part of twentieth century, utilizes a backswing with a flatter swing plane and a large hip and shoulder turn, here on the follow-through, golfer finishes in a relaxed upright “I” position and the momentum of player moving forward (McHardy et al. 2005). On the other hand modern swing utilizes larger shoulder turn, but smaller hip turn to build torque in the back and shoulders. The follow-through is characterized by the hyper extended back “reverse C” position (McHardy et al. 2005).

Recent aspect of ‘modern’ golf swing can also be described as stretch-shorten cycle activity, in which the muscles of the lower, mid-section and upper body are rapidly stretched prior to shortening. The effective utilization of this cycle will enable the golfer to obtain greater distance, while the mechanisms underlying the improved power in stretch-shorten cycle than concentric actions remain controversial (Hume et al. 2005). Thus modern swing is thought to deliver more power to the shot and higher ball trajectory. It is now most popular golf swing, both in professional and amateur ranks (Hosea, 1996).

Research has also found that most common injury mechanism was during golf swing and low back pain has been identified as most common musculoskeletal problem affecting both amateur and professional golfers (McCaroll, 1996). As many injuries were related to the golf swing, asymmetrical nature of the golf swing and the larger forces associated with the swing may be again a predisposing factor in golf swing related injury (McHardy et al. 2007). The modern golf swing leads to greater angular displacement of the spine and is suspected as being a major source of injury suffered by both professional and amateur golfers (Stover, 1976).

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. 1993) and (Watkins et al. 1996) found out activities of these muscles during different phases of golf swing but they failed to report the type of golf swing they had studied.

Although the above literature provide 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 swing patterns. Documentation of myoelectric activity in these muscle during two different golf swing allow a better understanding of the stresses associated with golf swing and could lead to technique modifications that would minimize low back stress and injury risk. The aim of present study was to compare the lumbar and abdominal muscle activation using surface EMG during two different type of golf swing i.e. “Classical” and “Modern” golf swing.

Materials and Methods

Study Design:

Same subject experimental design was used for this study.

Participants:

Twenty two right handed male golfers belonging to Panthers Golf Club volunteered to participate in this study. All subjects gave informed consent before participating in this study. All were free of any orthopaedic 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. Golfers were debriefed about both types of golf swing (i.e. modern and classical) and appropriate visuals were shown to them prior to the start of study. They were told to do practice swings so that they can accustom themselves with the swings. Subsequently, golfers were asked to hit 10 maximal efforts shots of classical golf swings and 10 maximal effort shots using modern swing. As EMG used in experiment is a 4 channel one the first 5 shots of classical swing were taken using E.S. and I.O. muscles of both sides. Similarly, remaining 5 shots of classical swing were taken using E.O. and I.O. muscles of both sides. The same set up is used for the recording of EMG activity during the modern swing. 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 impedance =10 milliohm A/D converter with $\pm 5V$ input range). Following settings were used: bandwidth =10-500 Hz, input impedance =10m Ω , CMRR = 110 dB, maximum input voltage = $\pm 5V$, 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 L₂). 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, 2003). 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 Stastical 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:

Left E.S.: The erector spinae muscle exhibited EMG activity below 30% MVIC i.e. $29.22\% \pm 8.56$ in classical and $30.39\% \pm 9.92$ in modern swing during backswing. Activity in classical showed $31.73\% \pm 11.00$ and modern showed $34.01\% \pm 13.86$ MVIC during down swing phase. In impact phase both in classical as well as in modern swing activity continuously increased to $34.53\% \pm 13.76$ MVIC and $35.36\% \pm 12.54$ MVIC respectively. In follow-through phase of golf swing, in classical swing the EMG activity recorded were $33.40\% \pm 15.23$ MVIC and for modern EMG activity recorded were $46.51\% \pm 11.70$ MVIC (Fig. 1).

Right E.S.: Muscle exhibited slightly higher activity in classical swing ($29.75\% \pm 10.72$) and lower in modern swing ($27.53\% \pm 7.51$). During downswing phase activity was $32.27\% \pm 11.98$ and $34.22\% \pm 11.87$ MVIC and in impact phase it was $35.33\% \pm 18.03$ and for classical and modern swing respectively. In follow-through, during classical it showed 35.87 ± 18.48 MVIC and $46.62\% \pm 11.48$ MVIC was shown during modern swing (Fig. 2).

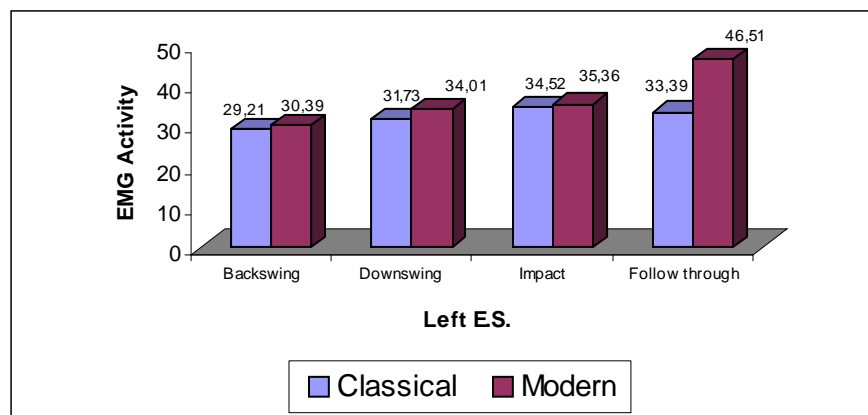


Fig. 1: Comparison of %MVIC of Left E.S. muscle between classical and modern golf swing.

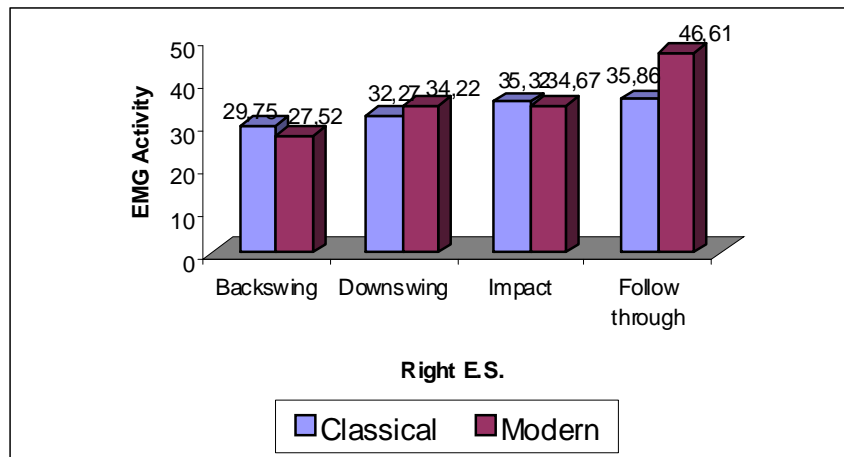


Fig. 2: Comparison of %MVIC of Right E.S. muscle between classical and modern golf swing.

External Oblique Muscles:

Right E.O.: The external oblique muscle demonstrated muscle activity of $18.85\% \pm 13.22$ and $15.78\% \pm 9.74$ MVIC in the classical and modern swing respectively, during backswing. The activity increased to $30.47\% \pm 18.23$ and $21.46\% \pm 18.32$ MVIC respectively for the classical and modern swing during downswing. It remained high in both swings during impact phase $32.74\% \pm 19.40$ and $22.85\% \pm 17.01$ in classical and modern swing respectively. During follow-through, EMG activity recorded was found to be $35.20\% \pm 26.37$ in the classical and $34.94\% \pm 34.18$ in the modern swing (Fig. 3).

Left E.O.: During backswing it demonstrated 20.63 ± 12.12 and $16.10\% \pm 8.07$ MVIC activity in classical and modern swing respectively. The activity during downswing increased to 26.86 ± 13.28 and $22.13\% \pm 14.74$ for the classical and modern swing respectively. It remained increased during impact phase where it was recorded 28.19 ± 14.84 in the classical and $26.49\% \pm 19.49$ in the modern swing. In follow-through phase, it exhibited $30.50\% \pm 17.22$ and $28.32\% \pm 14.93$ MVIC in the classical and modern swing respectively (Fig. 4).

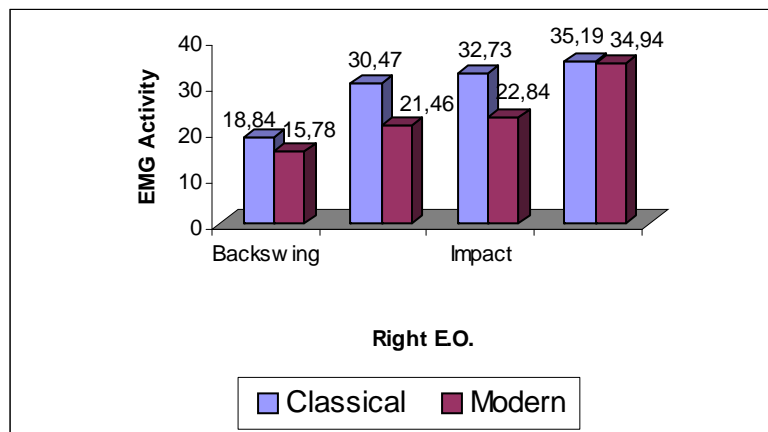


Fig. 3: Comparison of %MVIC of Right E.O. muscle between classical and modern golf swing.

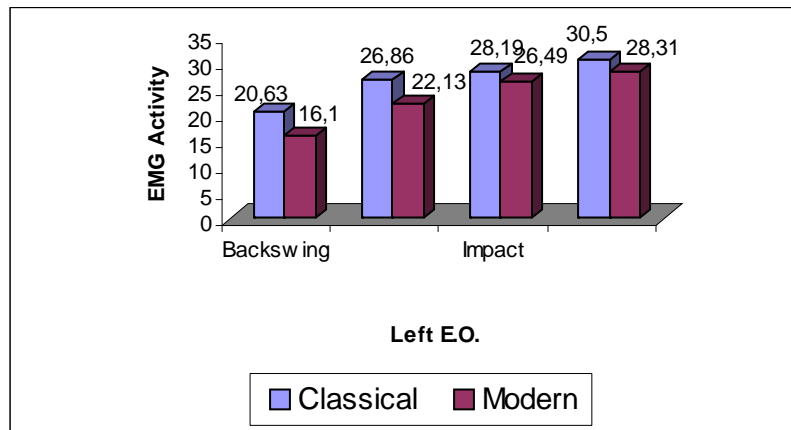


Fig. 4: Comparison of %MVIC of Left E.O. muscle between classical and modern golf swing.

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 internal oblique muscle demonstrated muscle activity of $22.37\% \pm 10.52$ and $20.31\% \pm 7.17$ MVIC in the classical and modern swing respectively, during backswing. The activity increased to $27.94\% \pm 17.20$ and $23.90\% \pm 14.76$ MVIC respectively for the classical and modern swing during downswing. It remained high in both swings during impact phase $29.44\% \pm 19.49$ and $26.02\% \pm 19.28$ in classical and modern respectively. During follow-through, it exhibited $32.83\% \pm 25.52$ in the classical and $26.35\% \pm 12.43$ in the modern swing (Fig. 5).

Left I.O.: During backswing it demonstrated $22.71\% \pm 12.87$ and $19.64\% \pm 9.40$ MVIC activity in classical and modern swing respectively. The activity during downswing increased to $39.30\% \pm 28.53$ and $24.27\% \pm 16.73$ for the classical and modern swing respectively. It remained higher during impact phase where it showed $37.53\% \pm 33.79$ in the classical and $25.82\% \pm 15.35$ MVIC in the modern swing. In follow-through phase, it exhibited $41.44\% \pm 35.55$ and $30.70\% \pm 20.46$ MVIC in the classical and modern swing respectively (Fig. 6).

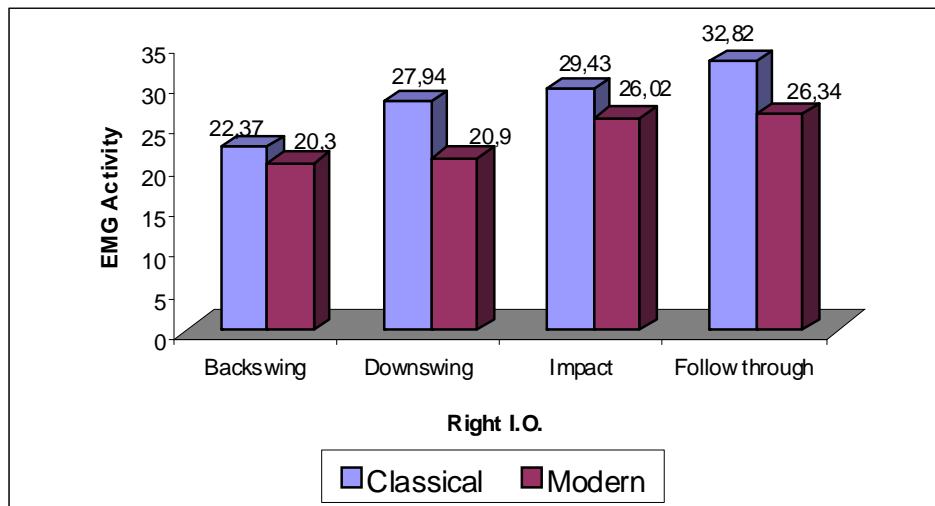


Fig. 5: Comparison of %MVIC of Right I.O. muscle between classical and modern golf swing.

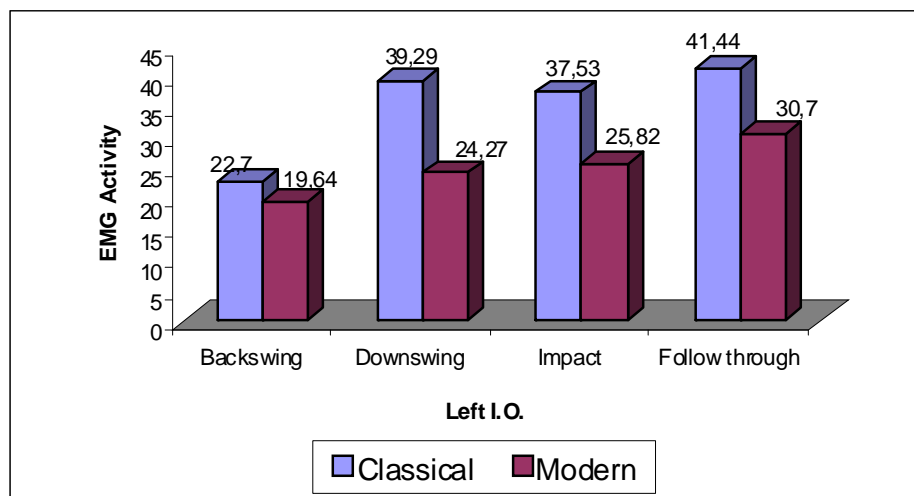


Fig. 6: Comparison of %MVIC of Left I.O. muscle between classical and modern golf swing.

Discussion

The result of this study on the activation of trunk muscles during the golf swing gives the sport physiotherapist an element on the specificity, thus helping him in understanding the technicalities of the popular sport golf.

The purpose of this study is to find out if there exists any difference in SEMG activity of lumbar and abdominal muscles during two different types of golf swing i.e. 'Classical' and 'Modern'.

In the current study, comparison was made between Classical and Modern golf swing for selected lumbar and abdominal muscles. Though studies in the past (Hume et al. 2005) have determined the injury patterns during golf swing, golf kinetics and kinematics and also muscle activation pattern (McHardy et al. 2005) and motor recruitment during golf swing no reference of which type of swing 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 both right and left E.O. (fig. 3, 4) and I.O. (fig. 5, 6) during back swing were found to be lower in modern swing as compared to classical swing in our present study; though not statistically significant ($p>0.05$). These muscle activities were found to be comparable with previous EMG studies done on trunk muscles (Pink et al. 1993) (Watkins et al. 1996).

Further, on comparing these values with other previous studies, the values of E.S. activity in modern swing were higher than that of EMG activity during backswing done in prior researches. On comparing muscle activity of E.S. muscle in our study we found that it was higher (though not statistically significant) for left side E.S. (fig. 1) muscle in modern swing and lower in right E.S. (fig. 2) than the classical swing.

We suggest that this phenomenon arises due to more work done by the corresponding muscle, which results in higher torque production at the lumbar spine. McHardy et al. (2006) also suggested that there was less torque production in lumbar spine during classical swing due to a larger hip turn.

We hypothesized that there were two possible reasons for less EMG (%MVIC) activity of I.O. and E.O. muscle in modern swing. Firstly we could hypothesize that the muscle was electrically silent during this type of swing and the second hypothesis was that the muscle was not fully activated to its full potential during this particular phase. As the movement pattern of classical swing and modern swing during the backswing phase is approximately parallel (McHardy et al. 2007). Thus, the chances of first assumption are not likely to be correct and I.O. and E.O. muscle should also be recruited to a similar extent. It is likely that the limited lumbopelvic rotation to the right which occurs during modern swing was the reason behind the lower activities of these muscles which we found in modern swing when

compared with classical swing. McHardy et al. (2005) has also suggested about the limited lumbopelvic rotation in his study.

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 (fig. 1, 2).

These E.S. activities were found to be more (not statistically significant) in modern swing than classical swing (fig. 1, 2) and we speculate this is a result of compromised E.O. and I.O. muscle activity in modern swing. Electrical activity of E.O. (fig. 3, 4) and I.O. (fig. 5, 6) during classical swing were found to be high with a statistically significant ($p < 0.05$) increase in right E.O. (fig. 3) and left I.O. (fig. 6) than contra lateral side in comparison to modern swing. This can be again due to less lumbopelvic rotation which occurs during backswing phase of modern swing as there is less stretch shortening cycle activity (in which muscle is stretched prior to shortening) of E.O. and I.O. occurs (Hume et al. 2005). Also oblique muscle functioned for flexion and rotation (Morris et al. 1962), which is limited in modern swing as suggested in literature, resulting in lower electrical activities of these muscles.

All these activities of E.S., E.O. and I.O. during both types of swings were found to be lower than what was said in prior researches. 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. This idea was also supported by a study done by (McHardy et al. 2006) which concluded that while studying golf swing various factors such as age, height, weight and flexibility of individuals should be taken into consideration.

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 and statistically significant ($p < 0.05$) decrease in right E.O. (fig. 3) activity in modern swing. As discussed above, it has been shown that the oblique muscles are more responsible for the rotation (Asmussen et al. 1962) that continues to occur and that the oblique muscles play a role bilaterally (Morris et al. 1962). Right side of Obliques (fig. 3, 5) was found to be more active than the left side (fig. 4, 6) which 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).

Once the ball had been hit (follow-through), E.O. (fig. 3, 4) and I.O. (fig. 5, 6) activity increased to some extent and noticeable but insignificant ($p>0.05$) change were reported in E.O. and I.O. muscles, which may be due to continuous axial rotation of trunk. This shows stability and mobility function of oblique muscles (Pink et al. 1993) (Lindsay et al. 2001).

Activity in E.O. (fig. 3, 4) and I.O. (fig. 5, 6) during modern swing continued to be lower than the classical swing. The E.S. muscle activity during follow-through phase was still notable, but the intensity was significantly higher ($p<0.05$) in modern swing in comparison to classical swing with left side showing more activity than right side (fig. 1, 2). This shows more work done by both E.S. muscles during modern swing in comparison to classical swing. This may be due to the reverse “C” position of spine which it attained during follow-through phase in modern swing. Thus it imparts more loads on lumbar musculature and posterior elements (Batt, 1993). It also results in degenerative changes in the lumbar spine (Stover et al. 1976). We suggest that here trunk continually rotates toward left side against gravity and falling backward to maintain reverse “C” position (more load on left side) which results in greater left E.S. activity than the right side (fig. 1, 2).

Grimshaw et al. (1999) in their study proposed that a higher level of muscle activity, coupled with the technique of the golfer indicates that the golfers may have experienced higher compressive and torsional loads in the lumbar spine. Thus results of our study indicates that these higher muscle activity in right and left E.S. during modern swing may predispose a golfer to more compressive force in the lower back, compared with the forces of classical swing.

Conclusion

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. This demonstrates the importance of the trunk muscles, as well as the potential for these muscles to fatigue (more chances in case of E.S.).

While the forces encountered in the lower back during the different swings have not been quantified, EMG evidence proposes that the modern golf swing produces more extension forces in the lower back compared with the forces of classical swing.

In this study, activation patterns of E.S., E.O. and I.O. muscles in Classical swing differs from activation patterns of same muscle when golfers performed Modern swing. Significant differences in E.S., E.O., and I.O. muscle activity may suggest inappropriate recruitment of these muscles in golfers during the modern swing.

Suggestions for future studies

There exists a need of targeted research into the force experienced by golfer during both type of swings. Also need of research arises to look for effect of swing type on both high and low skilled players? Further epidemiologic investigation into the type of swing used by golfers who suffered from low back injuries is required.

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