**Biology of Sport, Vol. 25 N°1, 2008**

# THE EFFECTS OF COGNITIVE ANXIETY ON THE BIOMECHANICAL CHARACTERISTICS OF THE GOLF SWING

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**Abstract**. The aim of this study was to examine the effect of cognitive anxiety (CA) on the biomechanical characteristics of the golf swing. Written informed consent was obtained from 9 subjects, with a range of golf experience (handicap range 4-23). Each subject was filmed under a low anxiety condition (during practice), and a high anxiety condition (during competition) and completed a revised version of the Competitive State Anxiety Inventory-2 (CSAI-2). Human movement analysis (Hu-m-an) software package was used to identify the clubhead speeds during the backswing, downswing, and impact time, along with the completion times for each phase. The absolute angle of the club to the vertical, and the relative angle of the forearm, wrist, and club hinge, at the completion of the backswing stage were also examined. CA intensity scores were significantly lower during practice than competition ($p<0.05$). CA interpretation scores indicate that anxiety symptoms during practice were significantly more facilitative to performance ($p<0.05$). The time taken to complete the downswing phase was significantly lower during competition ($p<0.05$). The combined backswing and downswing times were significantly lower during the competition trial ($p<0.05$). There were no significant differences between the practice and competition trials on any of the remaining swing variables measured.

***(Biol.Sport 25:3-11, 2008)***

*Key words:* Cognitive anxiety - Biomechanics - Golf - Swing mechanics

## Introduction

Numerous studies have attempted to describe the relationship between anxiety-related emotional states and sporting performance but the precise nature of the relationship has proved to be somewhat elusive [8,29]. Therefore only a limited number of studies have investigated the mechanisms through which anxiety may impose an effect on movement patterns and subsequent performance [5]. Research investigating the effects of anxiety on the kinematic motor characteristics of golf is limited. Previous studies have exclusively focused on changes to the movement patterns observed during performance of the putting stroke [23,24] and/or

employed 'artificial' anxiety manipulation protocols previously questioned by Collins *et al.* [5]. No studies appear to have examined the effects of cognitive anxiety (CA) on the biomechanics of the golf swing, which is regarded as the central element upon which the game is built [12].

There has been some research into the psychology of golf performance which have focused on anxiety [11], pre-performance routines [16], mood state [19], attention [25] and imagery [1]. There are also extensive reviews relating to the 'Yips' and 'Choking' in golf [4,26]. However to attain an accurate understanding of the golf swing it is necessary to apply a multidisciplinary approach incorporating biomechanical, physiological and psychological components, as well as motor control [7]. To date only one study on golf appears to have examined the psycho-physiological responses to CA in real, rather than contrived settings [20]. McKay *et al.* [20] reported significant differences in heart rate, CA and cortisol during a tournament compared to a practice round in elite golfers. However, their analysis failed to find any link between psycho-physiological parameters and performance.

The most important feature of the golf swing is the orientation of the clubface, the position of the clubhead, and the velocity at which it is moving at the moment of impact [12]. Several researchers have investigated the timing of the backswing and downswing phases of the golf swing [2,3,21], the clubhead speed at the point of impact [27] and the angle of the hinge at the completion of the backswing [22]. The methods a golfer uses to help guide and direct swing movements is decided through two means; by the way the performer thinks, and through the totally automatic or subconscious movements that are trained through practice [17].

It is important during a sport such as golf, that incorporates the execution of finely tuned motor patterns, to control the flow of adrenaline that is experienced when under conditions of increased anxiety which can change the characteristics of practiced body movements [28]. It has been suggested that the tempo of the swing can be significantly speeded up, and the backswing [28] becomes shorter, when a performer is experiencing elevated levels of anxiety. Therefore the aim of this study was to examine the effect of low state and competitive anxiety on the biomechanics of the golf swing.

## Materials and Methods

9 subjects were recruited for this study and were a range of abilities based on official club handicaps (handicap range 4-23). Prior to undertaking the study ethical approval was obtained from the Institutional Ethics Committee and written

permission received from a local golf club. Each subject provided written informed consent and none of the subjects had previously undergone psychological skills training.

Performance in the competition trial consisted of each subject being recorded striking their tee-shot from the 1st tee during 3 separate club competitions. The practice trial condition required each subject to perform 5 shots in a practice field, using the identical club to that used in the competition trial. The practice trial was carried out within 7 days of the final competition in order to limit any technical swing adjustments (e.g. following some form of golf instruction/training session). The data from the 3 competitions and 5 trials respectively were averaged, and considered representative of the subjects' normal performance parameters under a high and low anxiety situation.

Subjects arrived at the 1st tee at least 30 min prior to their allotted tee-off time. A standardised warm up consisting of hitting 10 shots into a practice net was undertaken prior to competition and practice. In order to limit the disruption to normal pre-competition routines, the subject used a club of their choice for the warm up. A revised CSAI-2 based on the version of Jones and Swain [13] was fully explained to each subject and completed 15 min prior to competition (CSAI-2comp) and prior to the practice session.

4 digitising sites were identified and marked with contrasting coloured tape. The 4 sites were: a) superior to the hosel of the club, b) inferior to the grip of the club, c) the lateral epicondyle of the left humerus bone, and d) the head of the 3rd metacarpal of the left hand. Each subject was required to wear a short-sleeved shirt, to enable the tape at the lateral epicondyle to be fixed to the skin and remain clearly visible at the backswing completion stage. By attaching this marker to the skin, any unwanted displacement caused by excessive movement of the clothing during the swing was avoided. The tape markers located on the club were placed around the shaft, to enable these sites to be clearly identifiable throughout the swing.

A Panasonic S-VHS 625 AG-DP200 video camera with a shutter speed of 1/2000, and a sampling rate of 100Hz was used. The camera was mounted on a fully extended Manfrotto 128RC tripod, situated on a level platform with a frontal view of the subject. A 1m measuring marker was placed parallel to the direction of play, as close to the ball as possible without causing interference, in order to allow a real-life scale to be applied to the digitising procedure.

Clubhead speeds during the backswing, downswing, and impact time and two angles at the backswing completion stage of the swing were analysed using the Human Movement Analysis (Hu-m-an) software. Digitising commenced at the address position, which was defined as the frame prior to the first movement of the

clubhead away from the ball. The backswing was considered complete at the frame in which the clubhead reached its most lateral position before changing direction. The subsequent frame was therefore considered the commencement of the downswing phase, and this was completed at the frame in which impact with the ball was made. These two angles measured were the absolute angle of the club shaft to the vertical, and the relative angle formed by the forearm, wrist, and club hinge.

*Statistical analyses:* Data were analysed using SPSS for Windows (SPSS Inc., Chicago, USA, V12.0). Descriptive statistics (means ±SD) were computed for CA, absolute angle of the club shaft to the vertical, and relative angle formed by the forearm, wrist, and club hinge, at the completion of the backswing, and clubhead speeds during the backswing, downswing, and impact phases under each trial condition. Differences in all variables between trial conditions were examined using repeated measures t-tests (RMt-tests). Level of significance was $p<0.05$.

## Results

The CA intensity scores were significantly lower during the practice trial ($p<0.05$) compared to the competition trial. The CA interpretation scores indicate that the anxiety symptoms during the practice trial were considered significantly ($p<0.05$) more facilitative to performance compared to those experienced in the competition trial. These data can be seen in Table 1 below.

**Table 1**
CA subscale intensity and interpretation scores during the practice and competition

| Variable | Practice | Competition |
|---|---|---|
| CA Intensity | 13.78±3.19* | 17.22±3.63 |
| CA Interpretation | +3.78±8.03* | +0.22±9.72 |

values are means ±SD
*significant difference between practice and competition ($p<0.05$)

There was no significant difference ($p>0.05$) in the time taken to complete the backswing phase between trial conditions. However, The time taken to complete the throughswing phase was significantly lower during the competition trial ($p<0.05$). The combined time taken to complete the backswing and throughswing phases was significantly lower during the competition trial ($p<0.05$).

There were no significant differences between the practice and competition trials for the average clubhead speeds during the backswing, throughswing, and impact phases, the absolute angle of the club at the completion of the backswing and the relative hinge angle at the completion of the backswing. These data can be seen in Table 2 below.

**Table 2**
Biomechanical variables during practice and competition

| Variable | Practice | Competition |
|---|---|---|
| Backswing Average (m/s) | 7.58±0.73 | 7.59±0.63 |
| Throughswing Average (m/s) | 21.06±2.15 | 21.48±3.12 |
| Impact (m/s) | 36.52±2.90 | 36.68±3.61 |
| Absolute Angle (degrees) | 93.93±36.53 | 93.95±38.23 |
| Relative Hinge Angle (degrees) | 89.46±19.58 | 91.28±19.26 |

values are means ±SD

## Discussion

It is widely acknowledged that the achievement and maintenance of an appropriate mental state prior to and during performance, is a crucial factor in competitive sport [14,15]. Despite this, no studies appear to have examined the effect of heightened CA on the biomechanics of the golf swing.

It the present study there was a significant increase in CA between the practice and competitive state. However, although a significant increase in CA was established between trials this did not translate into any significant effect on either the angles observed at the completion of the backswing or the club head speeds at any stage of the swing. The significant decrease in throughswing completion times indicate that a faster swing tempo was present, this did not translate to any significant increase in the clubhead speeds obtained at impact. As the clubhead speed is dependant on a number of swing variables, such as the mass of the clubhead, the amount of shoulder and hip rotation, and the level of wrist torque employed [12,27], the increase in swing tempo may have adversely affected the execution of one or more of these additional factors, thereby preventing any significant increase in the clubhead speed produced at impact.

Differences in the absolute and relative angles at the backswing completion point were observed between the practice and competition trials. However, the differences in absolute and relative angles followed no standard pattern across

subjects, and statistical significance was not attained. These results appear to offer support for the conclusion made by Collins *et al.* [5], who stated that there does not appear to be a consistent effect of anxiety on movement which applies to all participants. It appears that the precise nature of any anxiety-associated alterations in movement patterns relating to the golf swing, are highly subject and situation dependent.

A possible explanation for the absence of any significant effect of increased CA on the clubhead speeds and angles recorded, relates back to the predictions made by Hardy and Fazey's [9] catastrophe model. According to this model, when the CA experienced is low, any changes in PA should only have a relatively small effect on performance, possibly in the form of a mild inverted-U shape [10]. Thus, when CA remains low, the so-called performance 'catastrophe' may be avoided. The average CA intensity score of 13.8 for the practice trial, which increased to 17.2 during the competition trial. While a low CA intensity score during the practice trial would be expected, the competition trial was expected to produce a more significant increase in the CA response. Our data are similar to those previously reported with average CA intensity scores of 18.8 and 19.2 for a putting task [23], and pre-competition for elite golfers 17.1 [20]. Mullen and Hardy [23] suggest that these CA scores formed a limitation within their study, as the CA reported by participants in the high anxiety condition was less than that typically found in real competitions. Additionally the level of competition that the subjects in the current study were engaged in may not have been perceived as important enough to elicit a heightened state of CA. As Marchant *et al.* [17] state the perceived importance of outcome is relevant in the level of competitive trait anxiety in golf. CA is more likely to affect subsequent performance in high-standard competitive settings [31].

The average backswing times of 0.867s (practice) and 0.853 s (competition) are marginally quicker than previously reported by McTeigue *et al.* [21] of 0.91s and 0.90 s by Egret *et al.* [6] for amateur participants. Similarly, the average throughswing times of 0.329 s (practice) and 0.293 s (competition) are quicker than the 0.38s observed by McTeigue *et al.* [21] but slower (0.25 s) than Egret *et al.* [6] The results identified that the time taken to complete the throughswing phase was significantly less during the competition trial. Similarly, the total swing times observed in the competition trial were significantly less than those during the practice trial. It has previously been suggested that when a golfer is performing under conditions of heightened anxiety, they are often prone to increases in the tempo of the swing and/or a reduction in the length of the backswing [28]. Whilst this observation seems intuitively appealing, there appears to be little existing

empirical evidence to substantiate such a prediction. The significant reductions observed in the throughswing and total swing completion times during the competition trial, offer preliminary support for such a hypothesis.

Furthermore, the absence of any significant difference in the absolute angle of the club shaft at the backswing completion point indicates that the backswing was not curtailed or impeded. Therefore, it seems likely that the reduction in swing completion times resulted from an increase in the swing tempo, as opposed to a reduction in the length of the backswing.

The Conscious Processing Hypothesis proposed by Masters [18] provides a plausible explanation of the mechanisms through which anxiety may have affected the swing completion times observed in this study. This hypothesis suggests that when a performer is experiencing increased anxiety levels, they may attempt to regulate their performance by consciously controlling their movements using explicit rules, thus disrupting the normal automatic processing of the task [30]. According to Masters [18], the employment of conscious control, and the subsequent disruption to automatic task processing, inevitably leads to performance decrements. When a golfer finds himself in a pressure situation, for example on the 1$^{st}$ tee or towards the end of a good round, this disruption to the automised swing movement system and subsequent increased focus on specific swing variables, may result in a non-optimal performance outcome [28].

The results of the present study highlight some important effects of increases in CA experienced prior to a golf competition. It provides support for the efficacy of applied sport psychologists employing anxiety and arousal regulation strategies, to help golfers maintain biomechanical performance when under conditions of heightened CA.

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Accepted for publication 16.02.2007

**Acknowledgements:**
We would like to thank Dr Tim Rees for his advice in the preparation of this manuscript. There was no external financial support for this project