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Physiology & Health

Scott Addyman

ST20003228
IS THERE A RELATIONSHIP BETWEEN MOVEMENT COMPETENCIES, BALANCE AND CORE STABILITY WITH CLUB HEAD SPEED IN A GOLF SWING IN A RANGE OF GOLFING ABILITIES
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Abstract

The main aim of this research was to investigate whether certain physiological areas, specifically movement competencies, core stability and balance had a relationship with maximum club head speed (CHS) in a golf swing from different golfing abilities. Twenty two male golfers (mean age 20 ± 1.1 years), volunteered for the study and were divided into two groups based on their handicap (low handicap group = ≤16, high handicap group = >16). Participants completed the Functional Movement Screen (FMS) tests; a straight plank and two side planks (on left and right sides) and a Y-Balance test. Additionally swing analysis was completed using a simulator; participants hit nine golf balls at maximum effort using different clubs (pitching wedge, 5 iron, driver) and results were recorded.

Analysis revealed large negative correlations with handicap and CHS of the pitching wedge \( (r = -0.521) \) and 5 iron \( (r = -0.511) \). Moderate positive correlations were also identified with the straight plank and pitching wedge CHS \( (r = 0.330, P > 0.05) \) and right side plank and 5-iron \( (r = 0.312, P > 0.05) \). The FMS test, trunk stability push up and CHS with the pitching wedge showed large correlations \( (r = 0.569, P < 0.05) \) and the 5 iron moderate correlations \( (r = 0.439, P < 0.05) \). Large correlations were identified with the left leg on the active leg raise and ball speed recorded with a pitching wedge \( (r = 0.648, P < 0.05) \). Paired T-tests reported significant differences between high and low handicap groups for the pitching wedge and 5 iron CHS \( (P < 0.05) \).

The findings of this research suggest that lower handicap golfers possess greater competencies on the physiological tests, which could result in the development of greater CHS. Practitioners could apply these findings in strength and conditioning programs to improve golfing performance.
CHAPTER 1
INTRODUCTION
1.1 Introduction

With the rapidly growing participation rates in golf, it is increasingly difficult to get ahead at the top end of the game (Fradkin et al., 2004). The attainment of consistent, high performance in golf is what differentiates the lower-handicapped players, ultimately dictating their rate of success. There is a large body of research that has comprehensively studied the golf swing to analyse the components of the swing to ascertain what correlates with higher performance.

The nature of the golf swing is very complex, Bradshaw et al. (2009) explained the swing action as a holistic, bodily movement that has a sequence of kinetic movements to produce momentum to accelerate the club head to high velocities to strike the ball with power. When examining the development of sporting performance in golf, most focus has primarily been on the tactical, technical and mental aspects of the game (Fletcher and Hartwell, 2004; Gordon et al., 2009). The findings in some research have identified that the advantages of hitting the golf ball greater distances may heavily impact performance. Many golfers are now looking to improve their conditioning and physical state to develop their game further from this different angle. Recent studies have looked into the development of CHS and physiological factors that contribute to this.

Being able to generate greater distances has been reflected in terms of handicap in some studies. One of these studies is Fradkin et al. (2004) which found significant relationships existed between golfers’ handicaps and CHS, i.e. the lower the golfers’ handicap the higher their CHS was recorded. Therefore, in light of findings such as these, much of the research has switched to investigating the factors that effect CHS and thus directly influence distance and inevitably improve performance (Hume et al., 2005). The most likely explanation would be that greater CHS could result in the golf ball being hit a greater distance which has been identified to correlate positively by Gordon et al. (2009). Therefore these greater distances would result in the golfer being closer to the hole having taken less shots, which a previous study has found a significant advantage (Fradkin et al., 2004).
A major problem with the current research that has emerged is that CHS has not been accepted as a recognised performance measure in golf, but largely only identified as a performance measure in a laboratory setting. Since golf is a very demanding sport physically (Wells et al., 2009, Smith, 2010) a lot of the research has examined different physiological measurements that have been associated with improving the golfer physically and now research has started to look more into the physiological predictors of CHS, which has been identified as a significant contributor to golfing performance.
CHAPTER 2

LITERATURE REVIEW
2.1 Physiological factors

Research has been widespread in terms of investigating physiological factors and golfing performance, with some studies examining this area in depth (Sell et al., 2007; Lehman, 2006; Read et al., 2013). A number of physiological areas have been repeatedly examined within golfing research, but different methods and aims in terms of how the physiological area is tested and what area of golfing performance they affect have been used, therefore giving a wide range of understanding within this area. Strength, flexibility and power are three physiological components of performance that have been widely examined in studies through training programs or singular testing. However other physiological factors have also been investigated (balance, core stability, functional movement) to determine if any benefits can be observed in performance by developing these factors.

2.2 Strength and power

Wells et al. (2009) examined the physiological factors that correlate to golfing performance, the results of this study suggested the ability in performing a countermovement jump related to driver distances, these findings were supported by similar findings by Sell et al. (2007). However the methods used in this study were criticised by Torres-Ronda et al. (2011), since the driving distances were self reported by the participants, therefore cannot be considered as reliable due to the room for error that could have occurred from dishonesty or miscalculation. Many studies have reported findings that strength and power impact CHS. A study that investigated both is Hetu et al. (1998) in which male and female golfers completed an eight-week conditioning program, which targeted strength, flexibility and plyometric training with an aim to increase golfing performance. The findings revealed that CHS increased after the exercise program significantly up to 3 mph. This is most likely due to a larger number of motor units contracting at greater speeds whilst an increase in inter and intramuscular co-ordination resulting from the training could also lead to greater efficiency and therefore the ability to apply a greater force to the club generating higher speeds due to there being a reduced amount of limiting factors (Bowen and Stone, 1953). In concurrence, Westcott et al. (1996, 1997) reported comparable findings. However the major limitation of the Hetu et al. (1998) study is that there was no control group to measure a significant difference with the use of the training program.
In contrast to these findings, an issue that some golfers raise with strength training is that it could reduce their range of movement and restrict them functionally; therefore the efficiency of the movement would decrease significantly (Konik, 1995; Westcott et al., 1996). Many studies focus on increasing performance through the means of increasing strength and power, very few look at the flexibility and efficiency of movement. Furthermore, this issue has been raised by Cook et al. (2006a) who stated that many of the exercise tests result in an objective measure of the performance and are used to generate a performance measure, whereas they totally disregard any attempt to evaluate how efficiently an individual performs a specific exercise or movement.

2.3 Flexibility

Consequently having an ability to improve specific movements due to an increased range of movement could lead to greater efficiency and this can impact performance greatly. Many studies have looked into improving flexibility, one being Jones et al. (1998). This study focused solely on flexibility and discovered that CHS increased by up to 5.5 mph after flexibility training by means of proprioceptive neuromuscular facilitation, which allowed a greater range movement at the joint and thus increased functionality. The study by Lephart et al. (2007) was on a much broader scale, which incorporated other areas of fitness as well as flexibility. The research aimed to improve flexibility, strength and balance in an eight week training program to discover any improvements and correlations in golfing performance. To isolate CHS in the results, the findings showed that a more stable base (balance) with higher functional flexibility and strength of the upper body allowed for increased levels in CHS and therefore stated as an important physiological factor to develop. However, an implication of this study is that no control group was used, so conclusions of whether the development of these factors was the reason for this significant improvement could not be drawn. Overall flexibility is crucial as already identified by Lephart et al. (2007), but flexibility of the trunk is critical due to the movements of the hip and shoulder separation and rotation being essential to increased performance. The size of these rotations have been positively related to ball velocity and playing standard (Weston et al., 2013). The rotation that occurs here is a desirable movement kinematically to have in a golf swing to enhance performance. Since there is a greater ‘coil’ created in the upper body, Jobe and Moynes, (1986) emphasises that in theory increased trunk flexibility should transfer eventually into greater CHS. Another possible reason for this
finding could be due to the greater flexibility allowing a larger X-Factor to be produced. The X-Factor is a term for the relative rotation of the shoulders in respect to the hips during the backswing (Cheetham et al., 2000) and so with the increased range of motion, larger club head speeds can be generated (Smith, 2010), possibly due to an increase in time and distance to create them. As already identified these greater club head speeds can contribute to increased distance.

A study by Wells et al. (2009) discovered that flexibility had an impact on the distances obtained with a driver. Correlations were observed between the score recorded on the sit and reach test and driver distances. However limitations within this study have been recorded, one being the participants used in this study were all of a high proficiency in golf and consequently the results discovered could be limited only to highly skilled players. Another limitation could be that some of the testing was carried out under laboratory conditions and not the environment golfers actually experience. However despite these limitations assumptions can be made from the research, that developing flexibility can increase the CHS that a golfer can obtain.

Increasing flexibility can be achieved by increasing the length of the muscle, this reduces the overlap between the sarcomeres and allows for greater force production through the contraction, because when overlap occurs the sarcomeres are already shortened so full contraction cannot occur (Williams and Goldspink, 1977). Additionally by recruiting greater lengths of sarcomeres within a muscle, more powerful contractions could occur from the greater displacement of the increased length of the muscle fibres (Ahtainen and Hakkinen, 2009).

Recruiting more of the sarcomere results in greater lengths of muscle being contracted and subsequently greater forces can be generated within a single contraction (Edman, 1979). Being able to accomplish this would be hugely beneficial to the performer. Hibbs et al. (2008) reported that greater hip muscle movement and activation significantly affects the ability to produce power in the upper leg. This would be key if an athlete’s ability is impaired due to them not being able to activate and utilise the muscle because of the reduced range of movement from poor flexibility. Additionally, the greater range of movement generated through improved flexibility allows greater efficiency due to the individual moving more easily in some areas of motion and also those that were previously restricted, thus leading to a greater functionality of performance. This would be an
important area to measure because it involves a large number of the components of fitness; one way of analysing how well an individual can move functionally is a Functional Movement Screen (FMS).

2.4 Functional Movement

Many areas of standard performance screens and rehabilitation screens differ from FMS because some do not consider the basic mechanical movements that are required for a certain sport. Instead more focus is set on performance tests with basic movements such as sit ups, push ups, endurance runs, sprints and agility activities (Lippincott et al., 2000). However as outlined by Cook et al. (2006a), these tests need to concentrate more specifically on the exact range of motion of the sporting movement in its context and not just be a generic fitness test that is not relevant to the actions performed in the sporting movement.

In many performance environments, testing and screening sessions are used to help gain information on an individual's training and performance levels. These sessions could identify areas of strength and weakness and so corrective action could occur to help develop areas that are limiting their performance. However to do this the correct information would need to be obtained, this meaning to assess the individual in a specific movement for example, the golf swing. Similar or specific body movements would need to be tested in the correct manner to generate relevant information, rather than a performance test that has no impact on the action the individual is trying to improve. The biggest drawback with some performance strength and conditioning testing programs is that they primarily focus on gathering quantitative measurements of performance from basic performance tests. In some areas they fail to assess the individual's efficiency in terms of certain sporting actions or movements which sometimes can be completely overlooked (Cook et al., 2006a). A method put in place to overcome this is the FMS which aims to bridge the gap between pre-participation screening and participation screening in an attempt to test specific functional movements in athletic population groups (Cook et al., 2006a; Cook et al., 2006b). These are widely used and are accepted in the professional golf manufacturers' recommended conditioning for elite golfers, for example, the Titleist Performance Institute screening (TPI).
Being able to move and functionally recruit the precise muscles in the correct sequence and timing is important in golfing performance due to the unique nature of the technique required to perform the golf swing (Hume et al., 2005). When determining the fitness of a golfer, it is important to identify the factors set out by the Cook et al. (2006a) and Cook et al. (2006b) FMS because there is considerable room for variation in efficiency of the movement compared to the strength that someone has. Many golfers can be physiologically very developed but whether they can transfer the forces in their muscles, in the correct sequence and efficiently is something that would influence their actual performance with the golf club in terms of CHS as a performance indicator, rather than how well they can perform standardised performance measures. One area that is crucial in the efficiency of the golf swing transferring the energy produced by the working muscles in sequence is the core, because it connects the muscles working in the upper body and the lower body. Therefore the efficiency of the core muscles is paramount in relation to the sequence of the swing movement (Hume et al., 2005).

2.5 Core Stability

A study that has looked into the contractions of the core is Peterson et al. (2013), who found that using isometric contractions of the trunk and stabilisation exercises are more suited for testing core endurance rather than repetitive spinal flexion exercises (i.e. curl ups). This is due to isometric exercises being more suited to testing muscle size and strength. In a golfing context, studies have looked comprehensively into the functioning of the trunk to discover many performance benefits and as demonstrated by Peterson et al. (2013) these can be utilised to enhance performance. Another recent study by Weston et al. (2013) found that CHS increased in a number of golfers who participated in an isolated eight week core training program that consisted of a range of exercises to improve the strength and stability, as well as functional movement of the torso. Unfortunately, the reliability within this study can be questioned due to the fact that quality and quantity of the exercises provided to be completed by the participants were not monitored.

Another study that has investigated areas of the physiological condition of the core is by Hibbs et al. (2008). The research stated that increasing the strength of the core could lead to possible increased generation of force production. Also identified was that having an undeveloped, less trained core would decrease stability and thus could lead to inefficient technique, leading to decreased overall performance. More specifically the study
concluded by stating that having a more developed core would enable greater more efficient movements of the shoulders and arms. With the arms and shoulders being vital components in the swing, Hibbs et al. (2008) concluded by stating that having a more developed core would enable more efficient movements of the shoulders and arms, and with this in consideration, performance could be enhanced. Consequently, this finding would be significant for practitioners, with possible implementation in strength and conditioning programs. Similarly, Keogh et al. (2009) assessed anthropometric flexibility and muscular strength and endurance variables in an attempt to identify relationships between these measures and club head velocity. Twenty male subjects participated in the study, two different handicap groups were used to identify significant differences in variables. Results suggested that by developing the core in terms of its stability would allow the ground reaction forces created to be transferred to the club head thus increasing velocities. However, a small sample size and also the narrow range of handicaps and ages were identified as limitations in this study due there being small amounts of very specific evidence and much broader subject groups would be needed for investigation to reduce the uncertainty in the correct correlations stated.

Sell et al. (2007) investigated similar standards of golfers, however the sample size far exceeded those used in Keogh et al. (2009). This provides a greater volume of data and therefore an added element of reliability to the findings. Conclusions of this study stated that greater torso strength was identified in lower handicap golfers and also gave evidence that the strength of the lower torso plays a vital role in driving the golf ball long distances. Wells et al. (2009) reported similar findings with results from abdominal endurance showing to correlate with driver distance carry. Having greater strength of the core contributes to being able to stabilise and balance the body and this has shown to lead to benefits in performance, one noted by Hibbs et al. (2008) showing increased efficiency from greater levels of stability.

2.6 Balance

Balance is another component that could contribute to assisting efficiency and plays an important role in stabilisation and therefore could affect the performance of the golf swing. Balance has been defined by many, but could be broadly described as a process of maintaining the position of the body’s centre of gravity vertically over a base of support (Nasher, 1997). Winter et al. (1990) dichotomised static and dynamic balance, describing
static balance simply as the ability to maintain a base of support with minimal movement, while dynamic is described as someone’s ability to maintain or regain a stable position while performing a task on an uneven surface. These are important factors to think about when considering golf, since it is a sport incorporating a fast, whole body movement in a sequence and most of the shots are not played on a completely flat surface. The efficiency of movement is a crucial element of the golf swing and as identified in Smith, (2010) the inability to hold a stable position will lead to an ineffective movement and a poor range of motion, thus affecting the whole outcome of the desired shot. Additionally the complexity of the golf swing means that the vertical oscillation of the head and upper body needs to be minimal so that the consistency and quality of contact is not impacted. The quality can decrease if the club head makes contact with the ground before the ball, this would reduce the CHS when eventually making contact with the ball; subsequently this could lead to an off-centre strike on the clubface. This would not maximise the properties of the club head and therefore not generate the maximum ball speed required for hitting the golf ball longer distances (Williams and Sih (2007).

Variations in the vertical movement can largely be attributed to the stability of the base of support, which is provided by the legs. The motion of the hips within the swing means there will be some degree of difficulty in keeping the height and balance of the body throughout the golf swing, since many different body segments are moving at high speed. Furthermore, because of the powerful movements that occur during the swing, a firm base would be essential so the power can be transferred efficiently and successfully to the club through a kinetic chain of actions from the legs, through the hips, trunk and shoulders to finish at the hands and wrists (Hume et al., 2005). However, the measurements for most previous research have used very basic testing protocols, so it could be argued many limitations within the studies could be identified (Smith, 2010).

Balance has been identified significantly with higher levels of golfing performance in that more highly skilled players were found to report better scores than less skilled players by Sell et al. (2007). However, this study could be limited since it only investigated male golfers and only up to a handicap of 20. The method to test for balance was static, with minimal movement and does not reflect the balance in keeping the posture throughout the movement in the swing. The large subject group however and some of the methods and protocols used within this, add strength to the reliability of the findings. A study by Wells et al. (2009) investigated the correlation between static balance and performance
enhancements; the results from this study showed that with a greater level of static balance the performance indicators effected were accuracy of shots (greens hit in regulation and average putt distance after a chip shot), as well as finer movements over speed and distance, which lead to greater efficiency of the golf swing.

The main advantage of improving balance in terms of golfing performance is stated by Thompson et al. (2007), the study found that maintaining a greater stable axis of rotation would allow the muscles of the trunk and periphery to produce the powerful contractions that are associated with the downswing. This has been investigated by Mchardy and Pollard (2005) who identified a large activity in the periphery muscles of the trunk and therefore these specific active muscles could be developed to increase CHS. Some studies have used the Star Exclusion as their method of testing balance (Brassel et al., 2007; Thorpe and Ebersole, 2008). However certain implications within this method have been identified. Both Dalvin, (2004) and Kioumourtzoglou et al. (1997) found implications with the Star Exclusion Balance Test which would closely correlate to the Y-Balance Test due to the similar movements and methods used to evaluate an individual’s balance capabilities. It was discovered that the results of the test were heavily influenced by other physiological factors such as flexibility, most likely around the hip, gluteus maximus and medius, along with the tensor fasciae latae and other abductor and adductor muscles. Also the flexibility of lower back muscles especially erector spinae and upper leg muscles, in terms of the biceps femoris and the sartorius, rector femoris and vastus lateralis and medialis muscles, would need to be of a sufficient level to perform the movement required when undergoing this test, which also requires a significant level of strength and therefore a true measure of an individual’s balance ability is not achieved. Opposing this, Brassel et al. (2007) identified that other components of fitness such as coordination, joint range of motion and strength contribute to an individual’s balance. As suggested, balance plays an important role in overall performance of the golf swing and many different methods of analysing this performance have been used. A variety of cameras and computers are most commonly used to determine speeds of the club head and the ball, as well as other characteristics of the golf swing.
2.7 Swing Analysis

Limitations of swing analysis testing can be identified due to different protocols being used, for example, Thomson et al. (2007) and Healy et al. (2011) investigated swing analysis by both allowing participants to use their own clubs. This is a questionable area of reliability due the variation in individuals’ clubs, for instance some clubs could produce higher or lower swing speeds than others, due to different weighting, material or specification. Conversely Gordon et al. (2009) and Hetu et al. (1998) used the same club for the swing testing to reduce this variable. However, there are still implications with using the same club; all golfers swing in different ways and the club selected for the testing could suit some swings more than others and thus not provide true relationships and reliable results. Also psychologically the participant may feel uneasy about using unfamiliar equipment, so there are pros and cons for both methods and both could be seen as having limitations. Additionally results obtained would have various degrees of accuracy due to different technological systems being used.

2.8 Summary

From the previous body of research we can see many studies have found significant correlations with CHS and handicap (Read et al., 2013; Fradkin et al., 2004; Western et al., 2013) and so this is an element which would be considered when comparing the physiological performance between the two different skill levels. However many other studies have looked into the performance predictors of golfing performance and focus on how to target these individually by the use of exercise programs (Thompson et al., 2007; Western et al., 2013; Hetu et al., 1998), which have reported positive results, but major limitations have been identified within them. As identified by Cook et al. (2006a) many performance tests are objective measures and do not test the efficiency of the movement. Also identified are limitations in terms of the swing analysis and accuracy of it. Within the literature examined, a gap in the research that could be identified for investigation is that of whether there is a relationship existing between areas of core stability and balance and also how well an individual moves functionally and whether this could affect their CHS performance in a range of golfing abilities.
CHAPTER 3

METHODOLOGY
3.1 Participants

Twenty-two male participants with a mean age of 20 ± 1 years, took part in the study. The subjects were a wide range of golfers with handicaps ranging from 1-36, the average handicap being 16 (all handicaps are given in Appendix A). The group was split, handicaps of 16 and below were the low handicap group and 16+ were the high handicap group. All of the subjects were right handed. Subjects’ heights and weights were recorded and a pre-participation health questionnaire was completed before testing began. All anthropometric measures were recorded (Appendix A), average heights and weights were calculated; mean height: 181 ± 7 cm and mean weight: 85 ± 17 kg. The limb length from the anterior superior iliac spine to the ipsilateral medial malleolus was also measured to enable analysis of Y-Balance results.

3.2 Procedure

Initially the participants had unlimited time to warm up, stretch and prepare for the testing (Bradshaw et al., 2009), since each golfer has their own warm up routine to prepare for a round of golf. However a standardised warm up was completed to help ensure reliability of results, this consisted of specific golf stretches from Simpson and Kaspriske, (2004).

3.2.1 Functional Movement Screen

The first part of the testing was the Function Movement Screen (Functional Movement test kit endorsed by Functional Movement systems), which consisted of the seven exercises outlined by Cook et al. (2006a), Cook et al. (2006b). For each different exercise the participant was shown the exercise and explained the movement, they were allowed 3 practice trials and then performed 3 trials of the movement. The highest score was recorded on the 4 point scale (Table 1) according to the FMS manual and previous research (Cook et al., 2006a). Between each exercise participants were given 30 seconds rest. The test order started with the deep overhead squat followed by the hurdle step, inline lunge and active leg raise with both legs being examined separately on the left and right legs. Trunk stability push up was then followed by testing both left and right sides of the shoulder and rotary stability tests which completed the FMS testing.
Table 1. Scoring criteria used for the FMS protocol (Cook et al., 2006)

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<thead>
<tr>
<th>Score</th>
<th>Criteria</th>
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<tr>
<td>3</td>
<td>Participant is able to perform the movement correctly without compensation</td>
</tr>
<tr>
<td>2</td>
<td>Participant is able to complete the movement but performs with compensation(s)</td>
</tr>
<tr>
<td>1</td>
<td>Participant fails to complete the movement pattern or is unable to get into the position to perform the movement</td>
</tr>
<tr>
<td>0</td>
<td>Participant has any pain anywhere in the body at anytime during the test</td>
</tr>
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3.2.2 Y-Balance

The Y-Balance test was next on the testing sequence (Y-Balance test kit endorsed by Functional Movement Systems). The participants were given a set of 3 trials of each different lower body movement, with 3 practice attempts at the beginning to ensure they were familiar with the type of exercise. The order of testing was alternate legs starting with the anterior direction followed by posteromedial and finally posterolateral, the highest score out of the 3 attempts was recorded.

3.2.3 Core Stability

The final test to be performed was the measure of core stability and core strength, which was tested by the performing the isometric plank holds. The correct positioning of exercise was demonstrated to the participants; they were then required to hold in the correct position for as long as they could manage, ensuring good quality of the position throughout (figure 1).

However if form decreased further after a warning was issued then the test was stopped and the time recorded, (a stopwatch was required to time the participants’ trial). After this, the participant rested for two and half minutes and then performed a side plank, first on the right side then after another rest period, on the left side. The participant for the side planks used the elbow as the base of support and kept the hips up off the ground (figure 2).
The same protocol in terms of recording and completing the test was used for all three positions. The straight plank was used to test all of the muscles of the core rather than just the abdominals. The side plank was used because this position targets specific muscles and therefore greater muscular activation occurs, especially the external oblique and the gluteus medius. These muscles have been positively identified as key in the periphery muscles that make up the core (Hibbs et al., 2011).

**Figure 1.** Showing the correct isometric plank hold /bridge position (Graham, 2009)

**Figure 2.** Showing the correct isometric side plank hold /bridge position (Graham, 2010)

### 3.3 Swing testing

The swing testing was completed separately from the gym testing so the participants were in a fully rested state, with group one completing the swing analysis first followed by group two. Again the participants were allowed unlimited time to warm up and prepare as well as a standardised warm up. The testing began with four participants hitting balls (Pinnacle Gold, USA) into the net and when comfortable, rested for 90 seconds, then one by one hit three balls with maximum effort with a pitching wedge, (Titleist 925 DCI iron, with dynamic gold regular 300 gram shaft) with the simulator recording (Proshot Simulation - Sports Coach software). The other three participants rested while one was being tested, so there was sufficient resting time for each participant to be swinging at maximum rate. Certain results produced by the simulator were recorded, the main variable noted was CHS, but ball speed and smash factor were also observed, meaning some indication of the quality of the contact could be obtained. The same process was used for the 5 iron (Titleist 925 DCI...
iron with dynamic gold regular 300 gram shaft) and the driver (Titleist 909 D2 driver with an Aldila voodoo 66 gram shaft).

3.4 Statistical analysis

All statistical analyses were carried out using Microsoft Excel (2008 version 12.2.4 for Mac) and Statistical Package for the Social Sciences (SPSS for Mac version 22, SPSS Inc) was also used. Measures of the means and standard deviations of the data obtained were recorded and Pearson’s correlations were used to investigate correlations with any of the tests and CHS. Cohen, (1988) was used to determine the strength of these correlations. Paired T-tests were used to determine any significant differences between the two handicap groups.
CHAPTER 4

RESULTS
4.1 Handicap

From performing a correlation analysis the results show significant correlations have been identified with handicap and CHS, large negative correlations were shown between the pitching wedge CHS and handicap \((r = -0.521, P<0.05)\). Similarly, it was found that the 5 iron CHS also correlated largely and negatively with handicap \((r = -0.511, P<0.05)\).

4.2 Functional Movement Screen

The distribution of scoring on each of the seven tests of the FMS screen was calculated (table 2), the median score for each participant on the FMS tests was analysed with 64% of the participants obtaining a median score of 2 and the remaining 36% obtaining a 3. With the overall median score from all the participants being \(M = 2\). The total score of all results of the individual tests was reported, the mean of these was \(25 \pm 3.3\).

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Frequency = 1</th>
<th>Frequency = 2</th>
<th>Frequency = 3</th>
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</thead>
<tbody>
<tr>
<td>Deep overhead Squat</td>
<td>1=27%</td>
<td>2=59%</td>
<td>3=14%</td>
</tr>
<tr>
<td>Hurdle step</td>
<td>R=9% L=32%</td>
<td>R=45% L=50%</td>
<td>R=45% L=18%</td>
</tr>
<tr>
<td></td>
<td>R=45%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inline lunge</td>
<td>R=5% L=14%</td>
<td>L=41%</td>
<td>R=50% L=45%</td>
</tr>
<tr>
<td>Active leg raise</td>
<td>R=14% L=9%</td>
<td>R=32% L=45%</td>
<td>R=55% L=45%</td>
</tr>
<tr>
<td>Trunk stability push</td>
<td>1=0%</td>
<td>2=68%</td>
<td>3=32%</td>
</tr>
<tr>
<td>up</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shoulder</td>
<td>R=5% L=18%</td>
<td>R=9% L=23%</td>
<td>R=86% L=59%</td>
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<td>Rotary stability</td>
<td>1=27%</td>
<td>2=73%</td>
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</table>

R= right limb
L= left limb
Correlation analysis showed a number of exercises that reported significant moderate and large correlations with CHS. Trunk stability push up showed to have large, positive correlations with the CHS of a 5 iron and pitching wedge \((r = 0.569, P < 0.05)\) and \((r = 0.439, P < 0.05)\).

Ball speed was identified as having correlations with certain exercises from the FMS. The ball speed generated from the pitching wedge was found to correlate moderately with the total score of all the FMS tests \((r = 0.479, P < 0.05)\). A large, positive correlation was observed between the ball speed with a pitching wedge and the performance with the left leg on the active leg raise \((r = 0.648, P < 0.05)\). Another exercise that reported large, positive correlations is the trunk stability push up which was found to significantly correlate with the ball speed registered with a 5 iron \((r = 0.508, P < 0.05)\).

Total FMS scores were calculated in terms of their group, based on handicap. The mean for each group was calculated and results showed that the low handicap group had a higher mean FMS total score than the higher handicap group (low handicap group = 26 ± 3, high handicap group = 25 ± 4). However, results proved not significantly different in Paired T-test analysis \((P > 0.05)\).

### 4.3 Core stability

The means and standard deviations for the straight plank as well as the right and left side planks were reported: straight plank 141 ± 96 seconds, the right plank 69 ± 39 seconds and the left 67 ± 37 seconds. The results for the low and high handicap groups are shown in table 3.

Correlation analysis showed the core stability exercises to correlate moderately with some swing characteristics, however the results reported non significant \((P > 0.05)\). The straight plank results recorded a moderate, positive correlation with CHS with a pitching wedge \((r = 0.330, P > 0.05)\). Additionally the right hand side plank was a variable that reported moderate correlations with the CHS of a 5 iron \((r = 0.312, P > 0.05)\). However similar but slightly smaller correlations were observed with the left hand side plank and CHS, small correlations were recorded for the driver \((r = 0.237)\) and moderate correlations for the pitching wedge \((r = 0.246, P > 0.05)\) and 5 iron \((r = 0.294, P > 0.05)\). Additionally the results from Paired T-tests showed no significant differences \((P > 0.05)\).
The Y-Balance tests were interpreted using the framework set out by Move2perform. The mean total score from the test was 499 ± 51 cm, the mean limb length was 103 ± 5 cm. Also calculated was the difference of the scores between different handicap groups, the lower handicap group had a higher mean total score (1.8 cm) and also higher scores of 2 cm further on both legs in each direction. However very small, insubstantial correlations were identified with any of the swing characteristics. Additionally results from Paired T-tests reported no significant differences \((P > 0.05)\).

### 4.5 Swing analysis

The results from the swing testing show that the low handicap group had a faster mean CHS than the high handicap group. The lower handicap group reached speeds of approximately 6-10 mph faster. Additionally the low handicap group had greater mean ball speed on all 3 clubs. However Paired T-tests reported significant differences between the CHS in a pitching wedge and in a driver \((P < 0.05)\). In addition the ball speed reported significantly different with the 5 iron \((P < 0.05)\).
CHAPTER 5
DISCUSSION
5.1 Main findings

The major findings of this study show how some specific exercises can impact development in CHS, they can be summarised into a number of points. The first finding was that handicap correlated closely to CHS with a pitching wedge and 5 iron. The second was related to the core stability exercise (straight plank and side plank); the straight plank showed to correlate moderately with CHS with a pitching wedge and 5 iron. The trunk stability push up exercise in the FMS screen was another finding; it showed to have an impact on the CHS with a 5 iron. Other results showed that there was some impact on ball speed with specific exercises of the FMS testing. Additionally it was found that the Y-Balance had no significant impact on the CHS obtained; however, certain differences were identified between the low and high handicap groups. Reverting back to the original hypothesis, the results suggest that there could be some physiological factors that contribute more than others to CHS in a golf swing. However one area in this research, balance, did not correlate as strongly as others within CHS performances, but was still identified as potentially being an important measure of golfing performance.

5.2 Handicap

The results show a relationship between handicap and CHS, this helps us to understand that CHS is an important factor in golfing performance. The correlation suggests that the better golfer swings the club faster and this impacts their overall game. When looking to develop an individual’s golfing performance this is crucial to consider. The more force applied on the club results in higher velocities being reached throughout the swing. Thus greater speeds at club head are recorded, meaning larger impact forces on the golf ball, which in turn leads to the golf ball travelling greater distances (Hume et al., 2005). This therefore leaves the golfer closer to the hole and as found in a recent study, it provides a significant advantage (Fradkin et al., 2004). The results in this study supported the findings by Fradkin et al. (2004) who reported handicap to directly relate to CHS after performing linear regression analysis.
5.3 Functional Movement Screen

The FMS screen (Cook et al., 2006a; Cook et al., 2006b) helped to gauge how well an individual can move throughout a specific movement and also determine areas of strength and weakness within it. This screen was useful because it examined whether the movements performed were consistent. The participants familiarised themselves with the movements before performing three consecutive repetitions, since to determine the score, a degree of consistency and repeatability were required. This specifically links to golfers in that the swing rarely changes in highly skilled players. They can repeat the swing with very little variation and thus are consistent in the mechanics of their swing whereas a less skilled player can have slightly different mechanics in each swing they perform. Therefore a significant degree of consistency was required throughout. Thus raising the question of whether better golfers are able to move more consistently to provide more force on the club throughout the swing. The results when separated from the FMS scores showed that on average the low handicap group had higher FMS scores, suggesting that there is a degree of interaction between the movement capabilities and the ability to generate high club head speeds.

Out of the seven tests, one produced significant correlations with CHS, the trunk stability push up, which tests a range of different physiological measures. The aim of this is to test the ability to stabilise the spine in the sagittal plane during a closed chain upper body movement (Cook, 2010). The findings of this study could not only support the need for a strong functional core to generate CHS, but also the need for upper body strength. The results showed significant, positive, strong correlations with the score obtained on this test and CHS with a 5 iron and also a pitching wedge. Similarly significant strong, positive correlations were also found with the ball speed recorded with the 5 iron and pitching wedge. These findings relate to and in some areas match those in Daddio, (2012) who found that an inability or reduced range of movement and instability of the lower spine directly effects the power generated in a golf swing needed to hit the ball further distances. However an explanation for the correlation discovered in this study could be due to the range of muscles required to perform this test and as found by Mchardy and Pollard, (2005) during the downswing of the club the pectorials major were the most active muscle in the upper body and so greater strength in these specific muscles could lead to higher acceleration. Additionally Hume et al. (2005) stated that positive, strong relationships were found between bench press strength and maximum CHS performance. Consequently the
stability of the spine could be buffered by the degree of strength in the upper body because this a muscle group that is required predominantly within this exercise of the FMS screen. These findings on how the stability of the spine could relate to performance agree with Versteegh et al. (2008) who stated the position of the spine and the balance of it are essential in improving performance and reducing risk of injury and therefore give evidence to the relationship existing. This finding may however be more useful to reduce the likelihood of injury than developing performance. Reed and Wadsworth, (2010) state that the lower back is the most common injury in golfers and this is mainly due to the positioning of the spine and also the extensive rotations and movements that are imparted on it. Consequently correct conditioning could be crucial for golfers to prevent this from happening.

One other test from the FMS screen to provide positive results was the active leg raise and the ball speed recorded. This result found that the left leg score positively correlated with ball speed with a pitching wedge. It is clear that achieving a higher score on the test meant that collectively higher ball speeds were obtained. This could be an essential finding in that greater ball speed could result in greater spin rates, providing more control from unclear lies of the golf ball and also the ability to generate greater distances and strikes from the shorter clubs. Similarly, Thomson et al. (2007) found increases in golfing performance with greater flexibility and functionality of the lower extremities which could lead to greater contraction strengths and speeds.

A possible physiological explanation for this is the stretch shortening cycle, which provides elastic energy due to an eccentric contraction being followed directly by a concentric one and therefore providing quicker and more forceful contractions (Hume et al., 2005). Training and improving the strength of the muscles could create greater ability to store elastic potential energy due to the tension of the muscle fibres being more developed, meaning greater elastic energy could be produced. However too much strength training and aiming to develop the muscle can cause flexibility to decrease, resulting in a reduction in the range of movement. This can therefore affect the efficiency of the desired movement and consequently an optimum level of both strength and flexibility of the muscle is required to maintain maximum performance.
Alternatively, a possible reason for this could be that it is most common for right handed players to favour their right leg, thus this leg could be stronger and less flexible than the left. Also the left leg could be more commonly used as a support leg and therefore this could be a reason for the result in the FMS test. However Mchardy and Pollard, (2005) found that the left leg biceps femoris were the most active in the lower body during acceleration phase of the golf swing. Thus this test is highly based around the flexibility of mainly this muscle and assumptions could be made in its relationship to performance. Due to the fact that many of the left side muscles are activated to swing the golf club right handed, it would be crucial to consider strength and conditioning programs to facilitate this and enhance performance. A further reason for this result in higher ball speed recordings could be due to the club used. A pitching wedge is easier to hit than a longer club and thus performers are more likely to strike the centre of the club thus generating greater ball speeds (Peters et al., 2001).

5.4 Core stability

The second major finding was the results from the core stability tests; these tests reported to correlate significantly with CHS with the pitching wedge and the 5 iron. The core plays a vital role in the golf swing due to the whole body being involved in the movement, with the size of the rotations separating the lower and upper body being positively related to playing standard (Zheng et al., 2008). This separation is recognised as the X-Factor and is identified as a desirable factor to have in the backswing. This could be due to the ability to activate the movement of the hips by accelerating them more quickly on the downswing leaving a time lapse before the shoulders move and therefore making a larger angle of separation between the shoulders and hips. An additional explanation for this finding is that if the performer can hold their posture throughout the swing, a greater height is sustained, giving a greater swing arc as well as keeping the lengths of levers at their maximum, which can contribute to greater CHS. A study by Western et al. (2013) found that there was a negative correlation between core training intervention and handicap. This was not found to the same extent in this study. Similarly, the results relating to CHS found by Western et al. (2013) stated that developing and training the core lead to an increase in CHS 1.7 (± 4.3 %), which helps support the findings of this study in that there is a positive relationship between the strength of the core and CHS for a pitching wedge. Additionally a study by Wells et al. (2009) found that the strength and stability of the core was not just important when putting and performing chip shots, but significantly correlated
to 5 iron and driver distances. These findings, together with the results from this study demonstrate the importance the core could have in golfing performance and consequently the importance for developing the core in training.

The right side plank showed to have similar but marginally larger correlations with CHS than the left, with moderate to small correlations identified on the left side. The correlation of the right side plank score and the CHS obtained with a 5 iron shows a moderate positive correlation between the two variables. These results proved significant, because research by Mchardy and Pollard, (2005) state that in the acceleration of the downswing the most active muscle in the right side of the trunk is the abdominal oblique and as mentioned already, the side plank is heavily targeting the abdominal oblique muscles to perform this exercise. The requirement of this for the right handed golfer could be crucial because of the need to rotate the whole body onto the ball ensuring all momentum could be transferred. Additionally, as stated by Mchardy and Pollard, (2005), the pelvic muscles are required as a base for the trunk to rotate through the swing. In greater detail Aggarwal et al. (2008) found that to largely aid rotation, the left external oblique and right internal oblique both contract. Also found by Mchardy and Pollard, (2005) was the impact of the right gluteals, these play a large role in the extension of the right hip providing the energy to be exerted. The results showing marginally, smaller correlations on the left side with certain clubs can be verified to some degree in that the major usage for the muscles of the left side of the trunk are more active in the backswing to aid the rotation and not the acceleration phase. However the muscles of the left side perform a contraction to provide a pivot point for the rotation of the right hip. The different roles the muscles of the trunk perform can help to explain the small difference in the results over the left and right sides performances. Also the fact that muscles of the trunk are being conditioned specifically for their required movement through practice and play could be another contributor to the slight differences identified.

A similar study completed by Watkins et al. (1996) helped give evidence of the importance of the activation of muscles of the trunk to allow maximum power to be exerted by stabilising and controlling the loading response. This also helps to support the correlation between the stability of the trunk and CHS. Without stability the core power required to generate greater velocities to move the club faster through the swing is limited. Aggarwal et al. (2008) compared the muscle activity in the lumbar and abdominal muscles between different skill levels of golfers. The results suggested, though not statistically different, that
during the acceleration/forward swing phase there is greater activation of the right side abdominal muscles as well as lumbar ones as opposed to the left. This could be a possible explanation for the results seen in the present study, that the right side seems to have more of an impact on the velocities of the club. It was also discovered that in highly skilled players there was greater muscle activity in the left external oblique and both internal obliques than less skilled players.

Furthermore, analysis of results from this study agree with these findings since the lower handicap group on average had greater swing speeds on all 3 clubs (approximately 6-10 mph) as well as higher mean scores on all 3 of the core stability tests (approximately 9 and 25 seconds longer). However, the results from the Paired T-test found no significant differences were identified between the groups on the core stability tests, but were significantly different in terms of CHS with a pitching wedge and 5 iron. The impact of the stability and strength of the core could play a vital role in this performance. This finding could be due to the technical level of the lower handicap group’s swings being more advanced, allowing them to transfer greater force to a longer shafted club, thus generating higher CHS, whereas the higher handicap group would be less technically developed (Bradshaw et al., 2013). Another consideration is the difference in shaft length between the driver and 5 iron. Kenny et al. (2008) reported increases in club head velocity with an increase in shaft length in low handicap golfers. Also the driver being lighter and having a longer shaft means higher swing speeds are expected.

5.5 Y-Balance

Balance, as identified by Hume et al. (2005) plays an important role in the set up phase of the swing, helping to hold a firm base for forces to be transferred and exerted. Without this ability to hold the posture throughout the swing, power could not be applied to the club head and therefore reducing speeds and distance as a result. Furthermore, dynamic balance is required in the weight transfer throughout the golf swing more than as a supportive measure. Although minimal correlations were identified in this study, balance was important to consider due to the part it plays in the environment that golf is performed in.
A study completed by Kras and Abendroth-Smith, (2001) tested the duration of static balance by using a one-legged stance test (stork test) with both open and closed eyes, with scores ranging from 4-60 seconds in duration, whereas a study by Sell et al. (2007) investigates different movements of balance and found that lower handicap golfers had significantly greater balance than higher handicap golfers. This is an important area of fitness to have due to variation in the environment in terms of different gradients and surfaces golfers have to position themselves in to perform certain shots, for example on an up or down slope, or in a sand trap. Therefore, having developed balance has shown to have an effect on the ability to execute these shots successfully (Wells et al., 2009).

The results of this study suggested that the low handicap group recorded higher scores on the test overall than the high handicap group. The difference of the overall scores was 1.8 cm, while the difference between the two legs was 2 cm on both legs. This evidence could be a small indicator of the effect that balance has on the golfer’s performance in that the more skilled golfers were able to obtain higher scores, which would agree with the findings by Sell et al. (2007). However other physiological measures could have contributed to this result, for example the contribution of the core muscles in keeping the centre of mass stable over the base of support throughout the swing and so a weakness within this area could lead to further implications. This could be in terms of the vertical oscillation of the centre of mass which could impact the quality of the strike, which suggests that there could be more significant physiological factors that contribute more to the performance on the balance tests as well as overall golfing performance.

5.6 Practical implications

The findings of this study could be used in a practical setting by coaches to look into strength and conditioning programs. By combining the findings and applying them alongside the basic measures of strength, flexibility and power, could ensure the optimum physiological conditions for golf are applied enabling the highest performance levels to be reached. It could be argued that there is an optimum level of fitness for golf, however there are many areas that are too specific and individualised to create a standard measure for all golfers. Thus meaning coaches would have to consider not only the basic physiological factors but also technical and individualised aspects.
One area specifically that could be getting more recognition is the importance of the functioning of the trunk in an elite setting, as it is a factor that is becoming more essential to performance as well as reducing injury. Additionally a minor area that may be used to greater extent in rehabilitation programs is stability of certain limbs or areas of the body. This could give benefits in allowing greater speed and power to be exerted with increased efficiency and with less risk of injury. In addition to considering stability, it would also be valuable to investigate the balance of the performer. Although not found significant in this study, others have proved the importance of balance in its relation to golf performance (Wells et al., 2009).

Another area that could be applied practically is looking into the movement competencies and how the efficiency of a movement can be impaired by the condition of the individual. Since the golf swing is a singular contraction of maximum effort which is a very fast movement, rests between shots would be beneficial to the athlete so all available energy produced is used facilitate the speed and motion of the swing. So by coaches increasing the functionality of their players’ performances, the individual can reduce the amount of impaired energy/force or increase the amount of energy/force they can produce during the movement. As briefly mentioned these areas could be used in the rehabilitation of golfers, this could provide certain benefits in that it could reduce the risk of becoming injured again. From this it could be argued that conditioning can be developed further even though some areas are already applying this, greater quantities could still be applied. Furthermore, it could be debated whether there are other performance measures of the swing characteristics that are unknown as well as physiological testing that are more closely aligned with golfing performance.
CHAPTER 6
CONCLUSION
6.1 Conclusion

In conclusion, the research gave some insight into the relationship between movement competencies, balance and core stability with CHS in a range of different golfing abilities. The main findings of this study were:

- Large negative correlations with handicap and CHS with a pitching wedge and 5-iron.
- Moderate correlations identified with the straight plank and CHS with a pitching wedge.
- The FMS test, trunk stability push up reported large correlations with CHS and a pitching wedge and moderate with 5 iron.
- Significant differences were identified between the low and high handicap groups for CHS with a pitching wedge and 5 iron.

The study has helped provide areas that golfers could improve to develop greater CHS, which some studies have shown to affect handicap (Read et al., 2013; Fradkin et al., 2004). Many areas within the study show significant relationships between the physiological tests and the swing characteristics. This could be used at all levels of golf to help develop performance further.

6.2 Limitations

A main limitation that can be identified with this research is that the testing of the physiological measures was in a laboratory-based environment and this is far from what the golfers experience when participating in golf. For example, the FMS exercise deep overhead squat could have been performed on certain inclines or declines to try to mimic further the conditions that golf is played in.

In more detail, the testing on core stability through the use of a straight plank and side planks, which are isometric contractions, focuses on core endurance, rather than stability. This is mainly due to the fact it is difficult to replicate the exact movement the core contributes within the golf swing and so proves problematic when testing (Morrissey et al., 1995; Behm and Sale, 1993; Lehman, 2006). Conversely to these limitations, research by Mchardy and Pollard, (2005) identified that the major muscles in the lower body associated with the acceleration in the downswing were the abdominal oblique and gluteus medius which are required when performing both types of plank, but not to the same degree as
used in the swing, which is a singular maximal contraction.

A limitation identified with an exercise from the FMS testing, is that the trunk stability push up requires more physiological demands than those it is primarily testing for. The exercise requires the trunk to transfer force symmetrically from the upper to the lower body and vice versa; so if the individual is unable to produce the required amount of functioning reflex stabilisation, then poor performance would result in not reflecting the true stability of the mid-section of the body. Additionally upper body strength and flexibility of the shoulders play an important role in the success of the desired movement and thus would not fully targeting the trunk but more upper extremities (Cook, 2010). Furthermore, with the exercise tests of the screening, although the specific criterion was followed, subject bias on the score given could mean there is still room for error.

Another limitation could be the measurement of the swing characteristics; the computer software cannot be 100% accurate in its measurements and so this would be reflected in results. For example, to some extent it cannot pick up the actual quality of the strike, which would have an impact on ball speed recorded. However, a major limitation with the statements and findings of golfer’s handicap and CHS is that there are many different areas of golf that contribute to their success in terms of handicap, for example putting ability and accuracy of shots. Additionally measures of other components of performance could correlate largely to handicap and one further limitation is whether this also applies to female golfers. Within this study the lowest handicap was 1 and the highest was 36 so a wide range was covered, however only 22 participants took part and so only a small sample was investigated in this area.

6.3 Future research

To develop the knowledge further, there are still many gaps that can be identified from this study, as well as in the existing literature. One being to investigate further the measurements of core stability and strength and how other areas of golfing performance are affected. Additionally it could be beneficial to further research more specific measures of movement competencies, which are directly related to the movement of the golf swing and therefore golfing performance. Currently many areas of physiological training and testing are difficult to relate specifically to the movements in the golf swing. Furthermore, specific conditioning for the smaller untargeted areas could be examined, such as
improving the strength of the hip flexors and extensors and the impact this could have on driving performance, due to them being heavily involved with the X-Factor concept (loading of the hips). Although some research has covered the finer areas of the game, research into limb control and stability and how this could relate to areas such as putting and chipping would be beneficial.

In summary, the area of developing golfing performance is a field that is ever widening as scientific knowledge increases. This study contributes towards giving a better understanding of the many physiological areas related to the demands of golfing performance and the development of it in terms of the factors that make up the efficiency and effectiveness of the golf swing.
REFERENCES


APPENDICES
# APPENDIX A

## DETAILS ON PARTICIPANTS

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<td>Participant 22</td>
<td>16</td>
<td>177</td>
<td>105</td>
</tr>
</tbody>
</table>
APPENDIX B
CONSENT FORM

UWIC PARTICIPANT CONSENT FORM

UREC Reference No:14/03/31U

Title of Project: Is there a relationship between movement competencies, balance and core stability with club head speed in a golf swing in a range of golfing abilities

Name of Researcher: Scott Addyman

Participant to complete this section: Please initial each box.

1. I confirm that I have read and understand the information sheet dated 9/1/2014 for this evaluation study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.

2. I understand that the participation is voluntary and that it is possible to stop taking part at any time, without giving a reason.

3. I also understand that if this happens, our relationships with the Somerset Activity and Sports Partnership, with UWIC, or our legal rights, will not be affected.

4. I understand that information from the study may be used for reporting purposes, but you will not be identified.

________________________________________________
Name of person taking consent

Date ____________

________________________________________________
Signature of person taking consent

* When completed, one copy for participant and one copy for researcher’s files.
APPENDIX C
PROJECT INFORMATION SHEET

UREC Reference No: 14/03/31U

Title of Project: Is there a relationship between movement competencies, balance and core stability with club head speed in a golf swing in a range of golfing abilities

Name of Researcher: Scott Addyman Date: 9/1/2014

Information Sheet

Background

This study will consist of undertaking a number of fitness tests looking into certain parameters of fitness and how they relate to the participants swing performance. The tests for fitness will be conducted at the University of Wales Institute, Cardiff in the National indoor athletics arena.

In brief, there will be two parts to this study involving the participants:

- 1. The participants will be asked to complete specific exercises in the gym after being shown a correct protocol of how to perform each test safely and correctly.
- 2. Hit a total of 9 shots with provided equipment on a golf simulator

Why you have been asked?

You have been asked to participate in this study because of the benefits it could identify for you also because of your ability in golf is fitting to the desired participants for this research.
What would happen if you agree to participate?
Travel expenses would be covered transporting you to and from the venues. Measurements will be taken (height, weight) as well and health status in terms of muscular skeletal injury and all information required will be provided and instructed clearly during the research.

Are there any risks?
There are no significant risks that can be identified if the correct protocol is used as well and commitment from the participant. However we will not ask the participant to do anything they would not feel safe in completing.

Your rights
By participating in this study means you do not give up any of your legal rights. In the very unlikely event of something going wrong during the evaluation, UWIC fully indemnifies its staff, and participants are covered by its insurance.

Are there any benefits from taking part?
There are benefits of participating in that you will receive a full swing analysis along with a suggested sports conditioning program to enhance performance.

Do you have to participate?
There is no force from anyone making you participate it is your choice whether you would like to or not. If there is any reason to pull out mid study it is totally within your rights to do so.

Have you got any questions?
If at any point you are unsure about any part of the study you can ask us first hand or through a parent or guardian or coach to contact us directly.

Mr Scott Addyman 07944383039 st20003228@uwic.ac.uk
## APPENDIX D

### PRE-PARTICIPATION HEALTH CHECK QUESTIONNAIRE

Health and safety within this investigation is of paramount importance. For this reason we need to be aware of your current health status before you begin any testing procedures. The questions below are designed to identify whether you are able to participate now or should obtain medical advice before undertaking this investigation. Whilst every care will be given to the best of the investigators ability, an individual must know his/her limitations.

Subject name: …………………………………………………………………………………………

Date of birth: ……………………………………………………………………………………………

Doctors
Surgery Address: ………………………………………………………………………………………

Emergency Contact Name: ……………………………………………………………………………

<table>
<thead>
<tr>
<th>Question</th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Has your doctor ever diagnosed a heart condition or recommend only medically supervised exercise?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Do you suffer from chest pains, heart palpitations or tightness of the chest?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Do you have known high blood pressure? If yes, please give details (i.e. medication)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Do you have low blood pressure or often feel faint or have dizzy spells?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Do you have known hypercholesteremia?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Have you ever had any bone or joint problems, which could be aggravated by physical activity?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Do you suffer from diabetes? If yes, are you insulin dependent?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Do you suffer from any lung/chest problem, i.e. Asthma, bronchitis, emphysema?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Do you suffer from epilepsy? If yes, when was the last incident?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Are you taking any medication?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Have you had any injuries in the past? E.g. back problems or muscle, tendon or ligament strains, etc…</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Are you currently enrolled in any other studies?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. I have already participated in a blood donation program</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. Are you a smoker?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. Do you exercise on a regular basis (at least 60 min a week)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16. Describe your exercise routines (mode, frequency, intensity/speed, race times):</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If you feel at all unwell because of a temporary illness such as a cold or fever please inform the investigator. Please note if your health status changes so that you would subsequently answer YES to any of the above questions, please notify the investigator immediately.

I have read and fully understand this questionnaire. I confirm that to the best of my knowledge, the answers are correct and accurate. I know of no reasons why I should not participate in physical activity and this investigation and I understand I will be taking part at my own risk.

Participant’s name & signature: ……………………………………………………… Date: ……………

Investigator’s name & signature: Scott Addyman ……………………………………… Date: ……………
APPENDIX E
ETHICS STATUS

Date: 17/02/2014

To: Scott

Project reference number: 14/03/31U

Your project was recommended for approval by myself, as supervisor prior to the project starting on December 3rd, 2013.

Yours sincerely

RSL

Supervisor
When undertaking a research or enterprise project, Cardiff Met staff and students are obliged to complete this form in order that the ethics implications of that project may be considered.

If the project requires ethics approval from an external agency such as the NHS or MoD, you will not need to seek additional ethics approval from Cardiff Met. You should however complete Part One of this form and attach a copy of your NHS application in order that your School is aware of the project. The document *Guidelines for obtaining ethics approval* will help you complete this form. It is available from the Cardiff Met website.

Once you have completed the form, sign the declaration and forward to your School Research Ethics Committee.

**PLEASE NOTE:** Participant recruitment or data collection must not commence until ethics approval has been obtained.

**PART ONE**

<table>
<thead>
<tr>
<th>Name of applicant:</th>
<th>Scott Addyman</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supervisor (if student project):</td>
<td>Rhodri Lloyd</td>
</tr>
<tr>
<td>School:</td>
<td>School of Sport</td>
</tr>
<tr>
<td>Student number (if applicable):</td>
<td>ST20003228</td>
</tr>
<tr>
<td>Programme enrolled on (if applicable):</td>
<td>SES</td>
</tr>
<tr>
<td>Project Title:</td>
<td>Is there a relationship between movement competencies, balance and core stability with club head speed in a golf swing in a range of golfing abilities</td>
</tr>
<tr>
<td>Expected Start Date:</td>
<td>01/09/2013</td>
</tr>
<tr>
<td>Approximate Duration:</td>
<td>6 months</td>
</tr>
<tr>
<td>Funding Body (if applicable):</td>
<td>Click here to enter text.</td>
</tr>
<tr>
<td>Other researcher(s) working on the project:</td>
<td>If your collaborators are external to Cardiff Met, include details of the organisation they represent.</td>
</tr>
<tr>
<td>Will the study involve NHS patients or staff?</td>
<td>No</td>
</tr>
<tr>
<td>Will the study involve taking samples of human origin from participants?</td>
<td>Yes</td>
</tr>
</tbody>
</table>
In no more than 150 words, give a non technical summary of the project

Investigate how movement competencies balance and core stability of an individual effects club head speed in a range of golfers of different standards (handicaps). Physiological testing will be performed using reliable recognised tests looking into some selected main areas of fitness, which are movement competencies (mobility) balance and core stability, to gage the ability of the golfer physiologically, there after on simulators test for their club head speed by using 3 different clubs (pitching wedge, 5 iron, driver). From this an idea will be obtained to see which areas of fitness directly correlate to club head speed.

<table>
<thead>
<tr>
<th>Does your project fall entirely within one of the following categories:</th>
<th>No</th>
<th>Choose an item.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper based, involving only documents in the public domain</td>
<td>No</td>
<td>Choose an item.</td>
</tr>
<tr>
<td>Laboratory based, not involving human participants or human tissue samples</td>
<td>No</td>
<td>Choose an item.</td>
</tr>
<tr>
<td>Practice based not involving human participants (eg curatorial, practice audit)</td>
<td>No</td>
<td>Choose an item.</td>
</tr>
<tr>
<td>Compulsory projects in professional practice (eg Initial Teacher Education)</td>
<td>No</td>
<td>Choose an item.</td>
</tr>
</tbody>
</table>

If you have answered YES to any of these questions, no further information regarding your project is required.
If you have answered NO to all of these questions, you must complete Part 2 of this form

DECLARATION:
I confirm that this project conforms with the Cardiff Met Research Governance Framework

Signature of the applicant: Date:
Scott Addyman

FOR STUDENT PROJECTS ONLY

Name of supervisor: Date:

Signature of supervisor: