QUANTIFYING THE GRADIENTS EXPOSED TO A PROFESSIONAL GOLFER DURING A ROUND OF GOLF

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Research has suggested that that when performing a tee shot a gradient slope of 4.4% (2.25°) and above it is noticeable to the golfer and may cause an adjustment to their normal stance (Linde, 2005). To quantify what gradients were exposed to a golfer during a round of golf an inclinometer was utilised to measure the gradient of shots in open play from around 16 golf courses across the UK. Twenty two right handed male professional golfers were recruited and the inclinometer was placed between the inside of the feet and the ball. The results showed that over 50% of shots where performed on an incline greater than 2.25° mainly ranging from 0 to (+/-) 10°. These results suggest that future research is required to investigate the effects of gradient on the mechanics of the golf swing.

KEY WORDS: inclinometer, base of support, slope.

INTRODUCTION:

Once a ball has been played down a fairway the golf ball must be played where it lies (Cella *et al*., 2004) and golfer cannot touch or improve the position of the ball and has to adapt to the conditions of that lie. To add to this challenge the golf swing is one of the most complex movements in sport. The feet are the only source of support for the action and the base they create is crucial to the golfer so that they can generate the correct body movements to perform the swing effectively (Dillman and Lange, 1994). An appreciation of the forces and torques generated during the golf swing is important for the golfer so they are able to perform the mechanics required to achieve an optimal and efficient golf swing by transferring the force to the ball (Barrentine *et al*., 1994). However, this task increases in complexity with the varying types of terrain gradient a golfer encounters on a golf course. The problem that has been identified is the golf swing research has been predominantly performed on a level flat surface. This is because the majority of practice facilities provide only a flat levelled tee area to perform in, although a flat level lie on a golf course is rare.

Different types of shots a golfer may encounter whilst on the golf course is the ball below the feet, encouraging the golfer to tilt forward, and the ball above the feet, which encourages the golfer to lean back on their heels (Madonna, 2001). They may also be exposed to a uphill lie and downhill lie meaning the golfer has to adjust their address position to allow for the unlevelled ground**.** Anecdotal coaching advice informs golfers to change the mechanics of their normal swing to deal with these sloped lies, adjusting such factors as knee angle, trunk position and rigidity of movement (Madonna, 2001), with no scientific underpinning of how this affects the golfer and their swing. Research by Linde (2005) states that when performing a tee shot a gradient slope of 4.4% (2.25°) and above is noticeable to the golfer and may cause an adjustment to their normal stance. This may mean that recommendations, both scientific and anecdotal, are not appropriate under the specific conditions of the golf course. Therefore, the aim of this investigation was to quantify the degree of gradients explored to a professional golfer during a round of golf.

METHOD:

Twenty two right handed male professional golfers (age: 26.67 ± 45.47 years; mass: 78.17 ± 5.48 Kg; Handicap: 0-6) volunteered for the study. All were free from injury and able to perform in the study efficiently with no health problems. Informed consent was obtained and

the subjects were free to withdraw from the study without prejudice at any time. The study had received university ethical clearance.

Sixteen golf courses of 18 holes were selected for the study ranging across 3 counties in the UK (Hampshire, West Sussex & Dorset). The round was played in groups of 3 or 4 subjects depending on subjects availability. The subjects' used their own clubs and equipment conducting the round as they would normally completing the 18 holes. The information provided to the subjects were to try and score as low a score as possible during the testing and use their normal shot selection.

The equipment used to assess the gradient was a dual axial inclinometer (LD-2M, level developments, Surrey, UK) and was selected because of its high accuracy (to 0.01°) and range (±30°). The subjects were asked to tee off at the start of each hole and then set themselves for the next shot. During this time the inclinometer was placed between the feet of the subject and the ball during data collection. Because of the small size of the inclinometer it was attached to a 1 metre ruler as this gave the gradient from the back of the feet to the ball. This was repeated for every shot in open play. Shots from the tee box were not included in the data collection as the gradient in these locations are intended to be flat and therefore may have affected the results from open play. Other shots that were excluded were bunker shots and putts on the green as these conditions were not appropriate for this study.

Figure 1 shows the 4 possible direction of gradient. For each measured shot a X and Y value were recorded whether it be positive or negative. The direction +X was defined as the ball above the feet (BA), -X was defined as the ball below the feet (BB). For the Y directions the positive was defined as an Uphill lie (UH) and a negative as a downhill lie (DH).

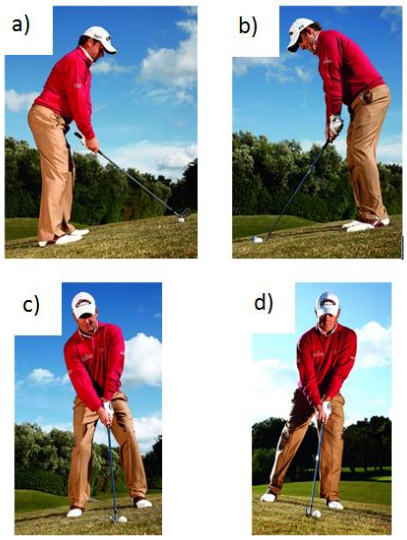

Figure 1: Definition of direction: a) Ball above the feet (BA) measuring in the +X direction b) Ball below the feet (BB) measuring in the –X direction c) Uphill lie (UH) measuring in the +Y direction d) Downhill lie (DH) measuring in the –Y direction.

To establish what gradients were being exposed to the golfers the recorded measurements were inputted into Microsoft Excel to allow the generation of a frequency table. Means and Standard deviations were also calculated.

RESULTS AND DISCUSSION:

Table 1 shows the results of the inclinometer data recorded during the study. A total of 953 shots were recorded during testing across the 16 golf courses with 1906 data points collected. Linde (2005) proposed that a slope above 4.4% is noticeable to a golfer when they are performing a drive. This equates to 2.25° and suggested that a gradient above this value the golfer may have to adjust their swing mechanics to compensate. The mean gradient lie in the positive directions show that BA and UH were both above 2.25° and in the negative direction BB and DH below -2.25° which still suggests a greater gradient.

Table 1: Mean (± SD) Gradient (°).

BA (°)	BB (°)	UH (°)	DH (°)
4.66 ± 4.47	- 4.26 ± 3.70	4.32 ± 3.19	- 4.89 ± 4.10

In the X direction 62% of the gradients were in the positive BA direction compared to the BB negative direction (38%) suggesting that more shots are played with the ball above the subjects' feet. For the Y plane 55% of the shots were performed on a gradient in the positive DH lie compared to the negative UH lie (45%) suggesting more shots on a downhill slope occur. Exploring deeper the data revealed that for all 4 directions measured over 90% of the shots occurred on a gradient of between 0° / 10° in the positive directs and 0° / -10° in the negative conditions.

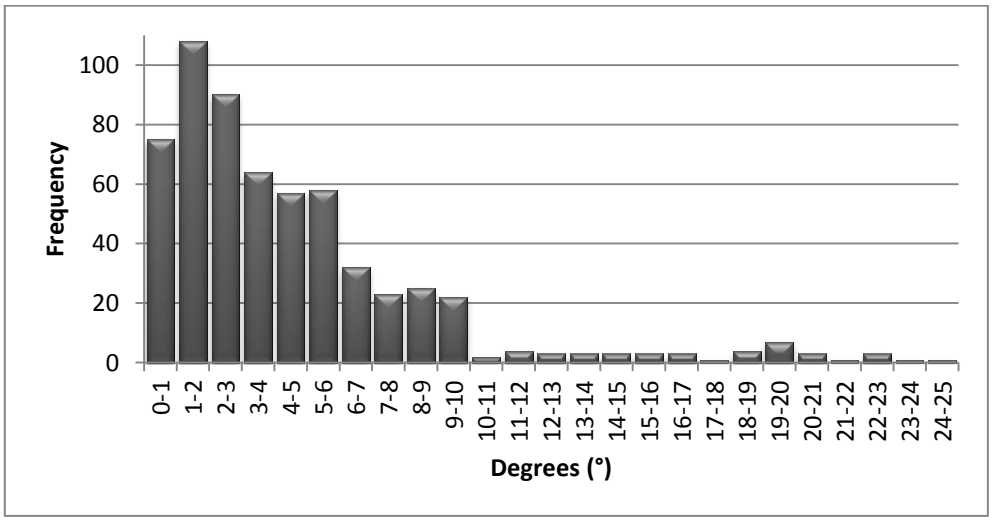

Figure 2: Example frequency chart. Ball above the feet (BA) measuring in the +X direction.

For all 4 directions over 50% of the shots measured the gradient lie was above 2.25° gradient, with BA having 54%, BB having 60%, UH having 52% and DH having 61%. This suggests that during a round of golf for over 50% of the time recommendations from research conducted on a level surface may not be as effective as it is unclear at this stage what effect the gradient has on the mechanics of the golf swing. With this being the case it is

recommend that future research is conducted on the effects of gradient on golf swing mechanics. This study suggests the range of gradient to be explored at between 0° – (+/-) 10°.

CONCLUSION:

The data suggested that in the four directions measured the gradient exposed to a golfer is mainly within a range of 0° / (+/-) 10°. This study has highlighted the need for research to investigate the golf swing when performed on a gradient. All previous literature has been conducted on a level surface and it can be clearly seen that a level surface during a round of golf is not common.

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