

A banner for the World Scientific Congress of Golf V, featuring a close-up of a golf ball on a green background. The text on the banner reads: "World Scientific Congress of Golf V" and "March 24-28, 2008 — Phoenix, AZ".

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**CHAPTER 31**  
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**An investigation into Weight Distribution  
and Kinematic Parameters during  
the Putting Stroke**

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**ABSTRACT**

This study examined the set-up position of 30 elite PGA professional golfers (2006-07 Season), in comparison with 30 amateur golfers (Handicap +3 to 9) while attempting the same putt of 25ft on a flat surface with a stimpmeter reading of 12. Video analysis at 50 frames per second was used to record kinematic parameters of the golfers' set-up and posture. Thirty PGA European Tour professionals and 30 amateur golfers performed their typical putting action whilst standing on an RSscan International 1.0 m x 0.4 m pressure platform. They used their own personal putter. The main difference between the amateur and professional golfers was in set-up. This was found to be significant with amateurs' weight distribution approximately 60% Right - 40% Left whilst the Professional Group was much closer to 50% on both sides at set-up. Student's t-test was used to compare the group means for each parameter with a level of significance set at  $p < 0.05$ . There is a trend to suggest that the wider the stance, the smaller the centre of pressure movement (sway) during the putting stroke. Although there was no significant difference in stance width, there was a significant difference in the total amount of sway, between the two groups of golfers.

**Keywords:** golf, putting, weight distribution, performance

## INTRODUCTION

Putting has been described as a game within a game on numerous occasions or even a 'black art'. It has caused more heartache and searching for the perfect stroke. Putting represents close to half the strokes most golfers would use in a full round of golf and is in many ways a miniature version of the full golf swing, yet it still remains the area of the game least taught... The majority of coaching magazines, manuals, textbooks suggest 'feel' as the key to success, along with a 'good technique'. A good technique is required in order to create the confidence necessary to hole putts. Pelz (2000) describes the putting stroke as only one of several different types of golf swing, yet accounts for nearly half of all swings made. However, what kinematic parameters constitute a good technique? The authors believe putting is a strength exercise, the ability to create a stable posture and pivot point is essential if the putter is to be returned consistently from address to impact. It is often stated by golf professionals it is best to stand comfortably at address, relaxed over the ball prior to hitting the putt. This creates a very individual style of putting. The two questions the authors would like to pose are firstly, what constitutes a comfortable set-up, and secondly, is comfortable the optimal position to execute the putting stroke.

## REVIEW OF LITERATURE

Cochran & Stobbs (1968) state that the putter head, while actually in contact with the ball, behaves almost as though it were disconnected from the shaft. The time of contact for a medium putt is approximately half a millisecond. Half a millisecond is a very short period of time. Therefore it increases the need to create a stable and solid base, along with a fixed pivot point in which to execute the stroke consistently. The address position is the first stage in developing a consistent and repeatable technique. This paper reports differences in set-up position between professional and amateur golfers whilst attempting the same putt on a flat surface.

## METHODS

### Subjects

The purpose of the study was to compare weight distribution and key kinematic parameters between amateurs and professionals in order to discover if there were significant differences between the group means in any of these parameters. 30 male PGA European Tour Golfers performed their typical putting action under the test condition for this study. A total of 4 out of the 30 professional subjects finished in the top 10 of the European PGA 2007 Order of Merit. All subjects were given a number of practice putts with their own putter in order to familiarise themselves with the required putt. Each subject putted towards a hole positioned 25 ft away in a straight line with a stimpmeter rating of 12. Subjects wore their personal golf shoes and attire. The trials were carried out over a period of six months during the competitive PGA European Tour 2007 season. The distance of 25 ft was chosen as the test distance because this is the length of a medium to long demanding putt. Each subject used their own putter and used it until they were able to hole the putt. This was deemed to be a successful putt. Every participant holed 6 successful putts. An average of the 6 putts was created for each individual.

### Apparatus

A Footscan® pressure plate 1.0 m x 0.4 m 4 sensors/cm<sup>2</sup> (8192 sensors total) with a sampling rate of 125 Hz was used to collect the data. The foot function was analysed using RSscan Footscan 7.9 2<sup>nd</sup> generation software. The range of the Footscan® pressure measurement system was 0.7N/ cm<sup>2</sup> – 155 N/cm<sup>2</sup>. The cross in Figure 1, represents the centre of pressure (COP) of the golfer at frame 1 (40ms before the beginning of the stroke – movement of the clubhead). The COP is the point on a body where the sum total of the pressure fields acts, causing a force and no moment about that point. In the example below, during the putting stroke the COP moves towards the heels of the golfer. The cross enables the four quadrants to specify the % weight distribution of the golfer at specific time intervals. For example in Figure 1: Left Heel = 14.72% / Left Toe = 28.37 / Right Heel = 31.41% / Right Toe = 25.50%.

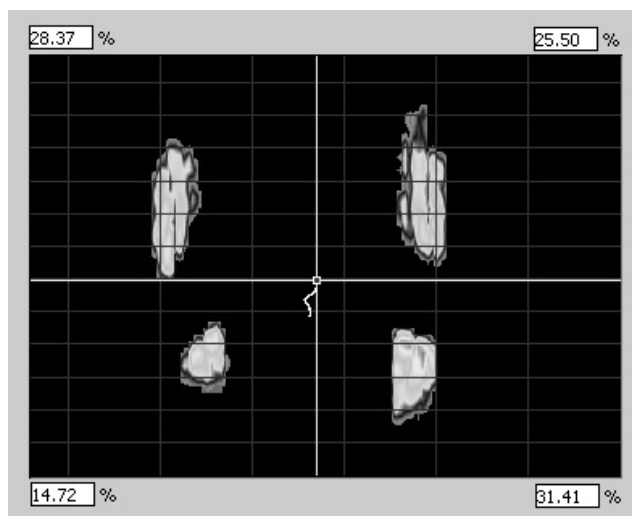


Figure 1 : RSscan Pressure Platform image of a right handed golfer.

The putting stroke was filmed using a standard digital video Sony TRV 900E camcorder. The camcorder was placed at 90° to the path of the golf ball, level with the putting surface. The RSscan Footscan® and Quintic Biomechanics 9.03 v14 software were synchronised using a 'key controller', a software package designed specially to link the two software programs.

All golfers used their normal putting stroke and personal putters. Digital video film (50Hz) was recorded giving the set-up, top of backswing, impact and follow through. After processing, the film was analysed using a personal computer running Quintic Biomechanics v14 video analysis software. Each video was calibrated in the horizontal plane using the pressure platform in the video (1m scale). All putting strokes were digitised at a rate of 50Hz. The putter head of each golfer was digitised and tracked using automatic tracking Quintic Biomechanics v14 and the resulting kinematic data smoothed using a low pass Butterworth filter (10hz).

The student's t-test was used to compare the group means for each parameter and investigate if any were significantly different. The level of significance was set at  $p < 0.05$ .

## RESULTS

### *Weight Distribution*

For each of the 60 golfers, the weight distribution for the Left and Right feet at set-up along with the weight distribution of Heels and Toes were calculated (see Table 1 & 2). The values were obtained for set-up 40 ms prior to the clubhead moving. The notion of 40 ms was used because a number of golfers actually had a body movement away from the ball before the putter head even moved. In addition the percentage of weight distribution in each quarter (Left Heel / Left Toe / Right Heel / Right Toe) was also calculated 40 ms before clubhead movement.

Table 1: N=30 Amateur Set-up : Weight Distribution % (S.E. = Standard Error)

					LEFT FOOT		RIGHT FOOT	
	LEFT	RIGHT	HEELS	TOES	HEEL	TOES	HEEL	TOES
Mean	40.57%	59.60%	47.70%	53.43%	19.57%	21.00%	27.17%	32.43%
± S.E.	3	5	4	4	3	3	4	3

Table 2 : N=30 Professional Set-up : Weight Distribution % (S.E. = Standard Error)

					LEFT FOOT		RIGHT FOOT	
	LEFT	RIGHT	HEELS	TOES	HEEL	TOES	HEEL	TOES
Mean	48.34%	51.66%	45.55%	54.45%	21.37%	26.97%	24.18%	27.48%
± S.E.	3	4	3	3	3	3	3	4

It is interesting to note that amateur golfers show a weight distribution at address of 60% right and 40% left, very similar to PGA recommended weight distribution for a long iron or even a driver at set-up. This would justify the statement made in the introduction that putting in many ways is a miniature version of the full golf swing – with the majority of coaching suggesting feel and standing comfortable as the key to success. What is a comfortable set-up for the majority of golfers?

Typically it is what they do the most of, i.e. practice the full swing. Only 5 amateur golfers had a set-up position of more than 50% weight on the left side. Interestingly, one amateur, a former international table tennis player had a set-up of 50% Left and 50% Right. For the amateur group there was a small bias in percentage favoring the toes at address 53%, again possibly reflecting the full swing set-up posture. However, it should be noted that there was a considerable variation at set-up ranging from 10% to 90% weight distribution for the toes at address.

The professional golfers showed a more balanced weight distribution at address of 52% right and 48% left (Range 29% - 75% Right Side) to that of the amateur golfers. This was significantly different ( $p < 0.05$ ) to that of the amateur golfers. Ten professionals had a slight bias towards the left side. However, the professional golfers at set-up exhibited an increase in percentage favoring the toes at address, 55% toes, ranging from 32% to 86%.

### Centre of Pressure Movement (Sway)

For each of the sixty golfers, the centre of pressure movement (Sway) was calculated for the total movement of the putt, start to finish (Mean Total Body Sway). The putting stroke was broken down into three categories: 1) Start (40ms before clubhead movement), to the top of backswing. 2) Top of backswing – Impact. 3) Impact - Finish. The amount of sway was calculated for each category.

Table 3: N=30 Amateur and Professional Golfers : Centre of Pressure SWAY (mm)  
SE = Standard Error

	Mean Total Body Sway	Start – Top of Backswing	Top of Backswing - Impact	Impact - Finish
Amateur	83.10*	17.61*	12.23	53.26*
± S.E.	6	3	4	5
Professional	64.34	12.24	10.13	41.97
± S.E.	6	2	3	5

Significant difference  $p < 0.05$   
Centre of Pressure SWAY (mm)

It is interesting to note that amateur golfers showed a significant increase in total amount of sway compared to the professionals. The amateur golfers on average swayed 83.10 mm during the putting stroke. This compared to 64.34 mm of movement for the professional golfers. This was significantly different for the two groups of subjects at  $p < 0.05$ . In each section of the putting stroke the average amount of movement was greater for the amateur group than for the Professional golfers. It is also interesting to note that the Start – Top of Backswing and Impact – Finish category were also significantly lower for the professional group.

It is the opinion of the authors that the lower the amount of centre of pressure movement, the greater the stability and balance of the golfer during the putting stroke. The lowest total amount of sway (mm) during the whole stroke was 23 mm, with 18 mm of this movement coming after impact. It is interesting to note that this professional golfer had a 52% left and 48% right weight distribution with also an equal split heels and toes.

The highest amount of movement was recorded post impact to finish. The finish of the stroke was calculated the moment the putter reached the furthest horizontal position from impact. The majority of this movement is a reaction to the impact as the head moves backwards (away from the target line). As a result the putter head can often be seen to rise steeply after impact. A number of amateur golfers had movements of 75 mm during this phase of the stroke.

The professional group has an average stance width of 28.84 cm, 4cm wider than that of the amateur group. This value may well explain some of the difference in COP movement. However none of the kinematic parameters presented below in Table 4 were significant between the two groups at  $p < 0.05$ .

Parameter	Units	Pros		Amateurs	
		Mean	SE	Mean	SE
Stance Width	cm	28.84	3.24	24.21	3.45
Height: Sternum – Floor	cm	136	4.10	135	3.39
Stance Width / Sternum Height	%	21.29	3.84	17.98	2.68
Ball Position / Stance Width	%	71.11	5.76	63.24	6.28
Ball Position: Sternum	cm	2.51	2.55	2.63	2.44
Ball Position: Left Eye	cm	-0.57	2.87	0.68	1.90
Ball Position: Bottom of Arc of Arc	cm	109	3	88	5

Table 4. Kinematic Parameters  
SE = Standard Error

## DISCUSSION

This paper has reported various differences in set-up position between 30 elite PGA professionals and 30 amateur golfers while attempting the same putt of 25ft on a flat surface with a stimp meter reading of 12. The main difference between the amateur and professional group was in set-up. This was found to be significant with amateurs approximately 60% Right - 40% Left whilst the professional golfers was much closer to 50% on both sides. There is a trend to suggest that the wider the stance width (professional), the smaller the centre of pressure movement during the putting stroke. Although there was no significant difference in stance width, there was a significant difference in the total amount of sway between the two groups. No significant differences were found between the kinematic parameters, most notably ball position and posture between the amateur and professional golfers.

## APPLICATION

The use of balance and pressure analysis is becoming more popular in the analysis of the golf swing. There however has been very little research into these parameters during the putting stroke. The pressure analysis enables the instructor to look at dynamics and body movement that the naked eye cannot see. Generally the instructor can see positional aspects of the golf swing such as address and top of backswing, but the balance / pressure software allows the instructor to critically review weight distribution and centre of pressure movement during the stroke. A good putting technique has the ability to create a stable posture and pivot point to allow the putter to be returned consistently from address to impact without manipulation. Standing comfortably at address and relaxed over the ball creates a very individual style of putting. However, comfortably and optimum balance (50% Toes / 50% Heels) are seldom the same position.

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