INFLUENCES OF GOLF CLUB SELECTION ON GROUND REACTION FORCES ON A NATURAL GRASS SURFACE

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Ground reaction forces were measured on natural turf at both feet during the golf swing using a driver and a 3-iron. Sixteen male golfers, with handicaps 0-14, performed 5 shots with each club while wearing a golf shoe with an alternative spike design. The front foot forces were greater than the back foot forces in all three orthogonal planes. At the front foot the maximum vertical force (Fz) generated was much greater when using the 3 iron by approximately 50%. The mean Fz range was greater when using the 3 iron of approximately 1.2 BW compared to 0.79 BW when using the driver. The back foot mean maximal Fz force generated was again greater for the 3 iron by 59% and mean Fz range approximately twice as great as compared to when using the driver. The Fx medial lateral force generated at the back foot was 60% greater when using the 3 iron.

KEY WORDS: club, force, golf, grass, shoe, spike.

INTRODUCTION: Traditionally, golf shoes have incorporated metal spikes that are attached to the outsole of the shoe to provide traction between the foot and the natural grass surface. In recent years, more ‘alternative’ spike designs have become popular, primarily due to the suggestion that traditional metal spikes may damage the natural grass surface of putting greens. The linear and rotational forces generated by the body musculature require a stable interaction with the natural grass surface if ground reaction forces are to aid a successful swing. In addition, these forces change when using different clubs alters the length and inertial characteristics of the swing. If the shear forces exceed the resistance offered by the shoe for either foot at any point during the swing, slipping would occur. Any irregular unexpected foot movement during the swing adversely affects performance (Slavin and Williams, 1995). The number of these alternative spikes on an out-sole, and their positioning alters drastically between footwear models. The effect of the altered out-soles on the ground reaction forces created and the subsequent swing dynamics remains unquantified. The only research that has measured the performance of these ‘alternative’ spike designs was that of Williams and Sih (1998), who found no difference in maximum and minimum ground reaction force values between traditional and alternative spike designs. However, this research was conducted indoors on an artificial turf surface.
A major drawback of research to date into golf shoe design features has been the difficulty of relating laboratory-based findings to the actual game of golf. The artificial operating environment of an indoor golf station may affect the performance of the golfer, and the outcome of the shot is unknown. Williams and Sih, (1998) stated that further shoe assessments were needed using a natural grass surface, and conditions where slip was more likely to occur in order to further define any effect alternative-spike out-sole designs may have on golf swing dynamics. The aim of this study was therefore to measure ground reaction force patterns on natural grass during the golf swing with different clubs, wearing alternative spikes, to compare the effects on these forces that are fundamental to the success of the golf swing.

METHOD: Sixteen male golfers used their own driver and 3 iron in an outdoor grass field testing station. Informed written consent was obtained, and habituation trials performed. Golfers' handicaps ranged from 0 to 14. New golf shoes of one design (see figure 1) were available in a number of foot sizes that were chosen by the subjects according to comfort. New Titleist DT white golf balls were used throughout testing.

Adidas 'Stripe Tournament' Sole.

Thermo Poly Urethane (TPU) Out-sole.

Ethylene Vinyl Acetate (EVA) Mid-sole.

Full Grain Leather Upper.

Full Grained Leather Lined

Fast Twist™ Alternative Adidas Spikes

Figure 1. Key features of golf shoe with seven alternative spikes.

The golfer adopted a normal stance with each foot on a natural grass turf covered Kistler 9851B force platform (Janaway and Dyson, 2000) and data was collected at 1000Hz while performing 5 shots with their own driver and a 3 iron. Data from the 9851B force platforms was passed to a Kistler 9865 amplifier and a 12-bit analogue to digital converter and collected using Bioware 3.1 software (Kistler, Alton,UK).

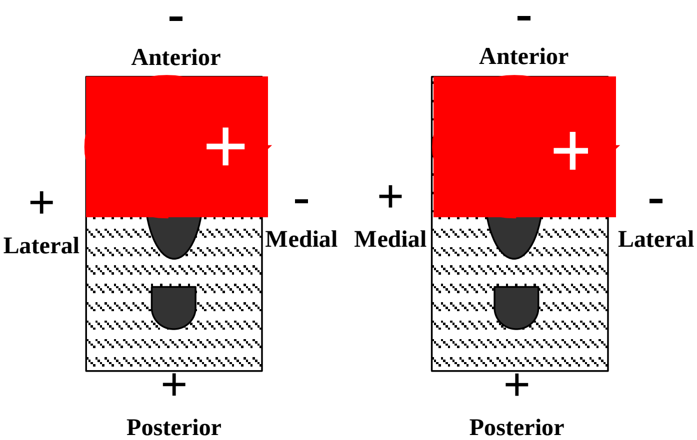

Figure 2. Analysis notations of vertical (Fz), anterior-posterior (Fy) and medial-lateral (Fx) forces.

Data was normalised to bodyweight before peak and ranges of forces were recorded for vertical and horizontal forces (see figure 2). A Peak Performance camera (Englewood, Colorado, USA) sampled at 200Hz and was synchronised to ball contact, allowing key points of the swing to be identified**.** A one-way analysis of variance with repeated measures was used to identify differences in forces when different clubs were used.

RESULTS: The mean mass of the 16 golfers was 79.4 $\pm$ 8.4 (Kg). The front foot forces for shots with each type of club were greater than the back foot as shown in table 1. At the front foot the maximum vertical force (Fz) generated was much greater ($P<0.05$) when using the 3 iron than when using the driver, by approximately 50%. This was reflected in the greater mean Fz range when using the 3 iron of approximately 1.2 BW compared to 0.79BW when using the driver. Figure 3 indicated that at the front foot the anterior-posterior forces (Fy) and medial-lateral forces (Fx) were similar whichever club was used. Figure 4 shows the changes in force generation during the different phases of the golf swing movement and the vertical forces greater than the horizontal forces.

Table 1. Mean ±SE maximal forces (BW) generated at the front and back foot during golf swings using a driver and 3 iron clubs. (* denotes P<0.05 between clubs)

	Club	Fz max	Fz range	Fy range	Fx range
Front foot (left)	Driver	0.792 ±.025*	0.790 ±.025*	0.249 ±.010	0.288 ±.015*
	3 iron	1.182 ±.055*	1.000 ±.056*	0.241 ±.013	0.336 ±.013*
Back foot (right)	Driver	0.487 ±.020*	0.330 ±.022*	0.209 ±.013	0.165 ±.008*
	3 iron	0.774 ±.028*	0.626 ±.027*	0.198 ±.014	0.264 ±.011*

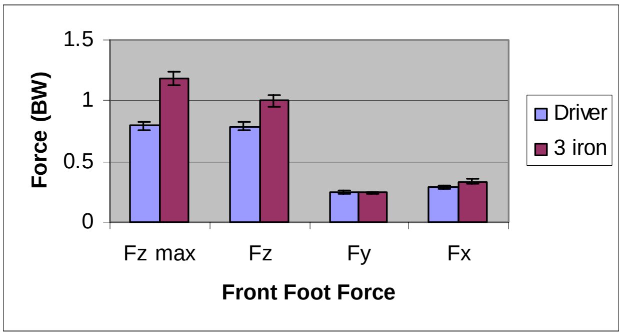

Figure 3. Mean forces (±SE) generated at the front (left) foot when using two different golf clubs.

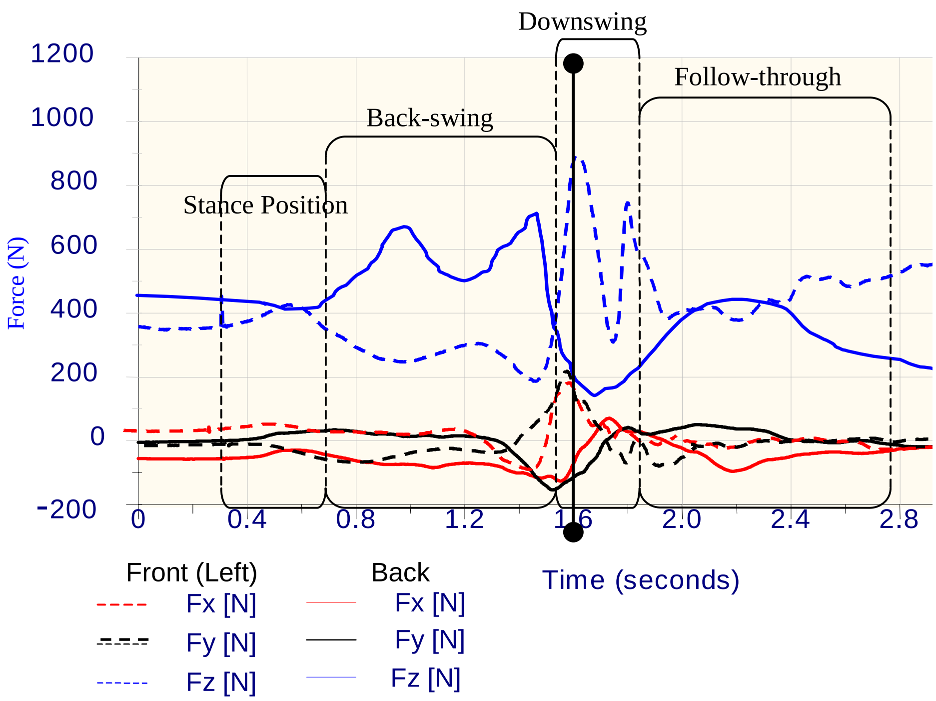

Figure 4. Action force trace identifying the stages of the golf swing with a 3 iron.

For the back foot, as shown in figure 5, the mean maximal Fz force generated was again greater for the 3 iron by 59% and mean Fz range approximately twice as great when using the 3 iron as compared to when using the driver. Also, the Fx force generated at the back foot was 60% greater when using the 3 iron.

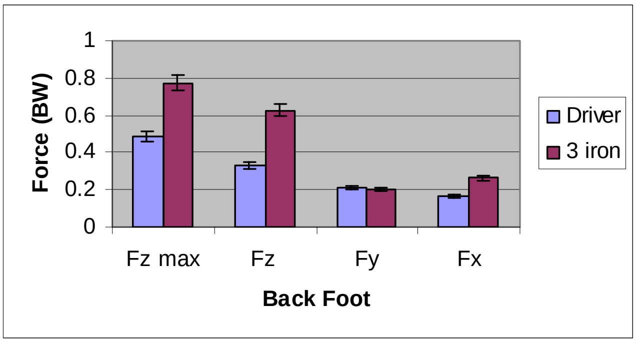

Figure 5. Mean forces (±SE) generated at the back (right) foot when using two different golf clubs.

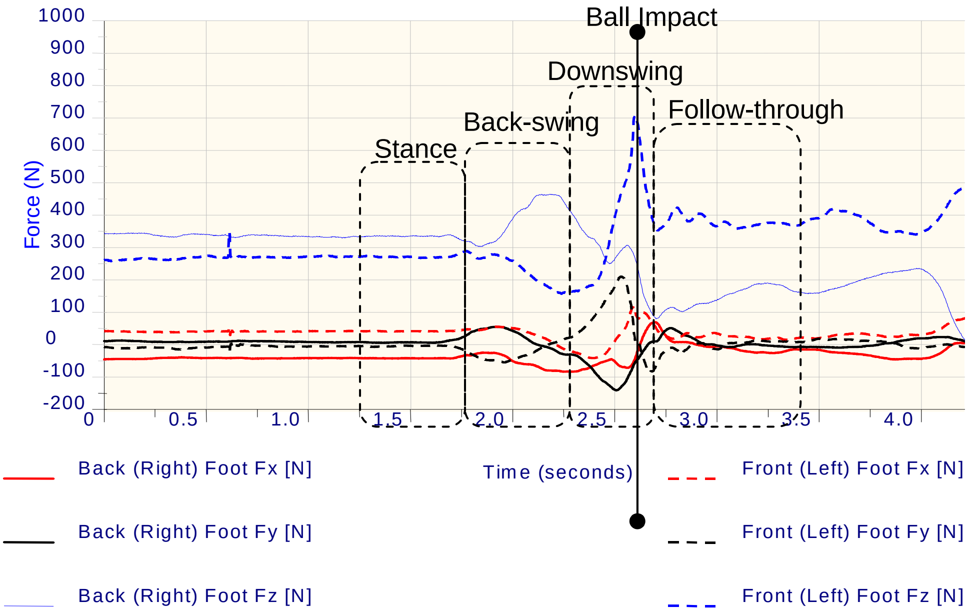

Figure 6. Force action trace identifying the phases of a golf swing with a driver.

DISCUSSION: A pattern of greater forces developed at the front foot during the golf swing was evident in accord with Barrentine et al. (1994) who reported ground reaction forces on an artificial turf surface. The vertical peak front foot forces identified in this study were greater than 1BW reported previously (Dillman and Lange, 1994, Williams and Sih, 1998, Koenig et al.1994), though less than the 1.6 BW reported by Williams and Cavangh (1983). This research clearly identified greater ground reaction forces associated with using the 3 iron in comparison to the driver in contrast to earlier reports in the literature (Williams and Cavangh, 1983; Koenig et al. 1994). All of these latter studies were conducted on artificial surfaces, not using natural grass at the shoe-sole interface that would occur in golf play. Altered traction of the shoe sole at the interface during the swing would have been evident in these studies. In this scientific literature various shoe designs were worn, with only Williams and Sih (1988) referring to an alternative spike shoe. It should also be borne in mind that there is a possibility that indoor testing may artificially moderate the swing process unless allowance is made for the importance of visual information.

CONCLUSION: The front foot forces were all significantly greater than the back foot forces in all three orthogonal planes. When golfers wore golf shoes of an alternative spike design, the choice of club influenced the shoe-grass interface ground reaction force. Vertical peak forces at the front foot and back foot were greater when a 3 iron was used in comparison to a driver. When testing for traction properties of golf shoes, it is suggested that iron shots be assessed.

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