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To Evaluate the Relative Influence of Coefficient of Friction on a Putted Golf Ball

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Purpose

Numerous studies (Epperson & Gadsden, 1993; Flom & Beuche, 1959; Hubbard & Alaways, 1999) outline the principles of static and kinetic friction and how these have an effect on golf putting, however no research has looked at the effect the surface has on the rolling characteristics of a golf ball. It has been suggested (Weber, 1997) that stimp meter readings can be used to measure the amount of friction that is present on the golf green. In critique of this method the stimp meter only assesses the amount of rolling friction that is present on the green and does not take into account the initial skid phase that occurs at the start of the putt. Green reading has consistently been found to be the biggest contributor to overall putting performance (Epperson & Gadsden, 1993; Karlsen et al. 2008; Laws, 1990), however there are very few practical implications that golfers can use to enhance this area. This study aims to determine the coefficient of kinetic friction of varying types of surface, before analysing the effect that they each have on the ball roll characteristics of a putted golf ball (i.e. distance taken for the ball to reach true roll).

Method

Two different methods of collecting putting data were used during this study; a putting robot and a human subject. An Odyssey (Callaway Golf Europe Ltd., Surrey, UK) White Hot #3 putter (putter length - 34”), with a 69º lie and 2.5º loft, was used for both methods. Five different Titleist Pro V1 golf balls were used during the study. These golf balls had a spherically-tiled 352 tetrahedral dimple design. All golf balls had three small black dots embedded on the side of the ball to allow the camera to identify and track the ball during experimental trials (see figure 1). For each surface thirty valid putts were tracked for the first 40cm of their travel, namely; a putting mat, rubber, MFC and compact carpet, via a high speed camera (360 frames per second). In order for a putt to be selected for analysis it had to meet the 'Quintic recommendations' for a 'valid putt' (see table 1). A numerical model was used to determine the mean coefficient of kinetic friction from each of the four surfaces. The means and standard deviations of each surface were calculated within a separate excel spreadsheet.

Results

The highest coefficient of kinetic friction for the robot method was obtained using the rubber surface ($\bar{\mu}$ = .29, σ = .01), whilst the lowest was MFC ($\bar{\mu}$ = .11, σ =.01). The distance to zero skid reflected this with the respective surfaces generating distances of 6.00 and 16.77 inches. The highest coefficient of kinetic friction for the human method was obtained using the rubber surface ($\bar{\mu}$ = .31, σ = .01), whilst the lowest was MFC ($\bar{\mu}$ = .10, σ = .01). The distance to zero skid reflected this with the respective surfaces generating distances of 5.65 and 17.37 inches (table 2). Results would indicate that that the greater the coefficient of friction, the smaller the distance it takes for a golf ball to achieve pure rolling motion (i.e. a negative relationship). Results suggest that both methods (robot and human) of measuring the coefficient of kinetic friction of different surfaces are comparable (figure 2).

Conclusions

The use of the 'Quintic Ball Roll' system as a measuring tool may be used by coaches to replicate putting green characteristics away from the golf course for players to familiarise themselves with the conditions in order to prepare themselves for competition play. This method may also be of use to green keepers who are looking to measure green speed, and may be a more appropriate method when compared with the stimp meter which eradicates the initial skid phase of the putt, suggesting it's inappropriateness as a measuring tool. Based on these suggestions it would be of interest for future research to investigate the relationship artificial surfaces, such as those used in this study, have with grass (outdoor golf greens). Manufacturing a number of artificial putting surfaces with diverse ranges of surface frictions would allow golfers and coaches to adapt their game, thus improving putting knowledge and performance.

References

1. Epperson, B.P & Gadsden, E.T.: Golf. Birmingham, Ala. Pat. 5,383,664 (1993)
2. Flom, D.G., & Beuche, A.M.: Theory of rolling friction for spheres. Journal of Applied Physics, 10, pp.1725 -1730 (1959)
3. Hubbard, M., & Alaways.: Mechanical Interaction of the Golf Ball with Putting Greens. Science and Golf Ill: Proceedings of the World Scientific Congress of Golf, 54, pp.429 – 439 (1999)

   Weber, A.: Green speed physics. USGA Green section record, 35(2), 12-15 (1997)
4. Karlsen, J., Smith, G., & Nilsson, J.: The stroke has only a minor influence on direction consistency in golf putting among elite players. Journal of Sports Sciences, 26(3), .243-250 (2008)
5. Laws, W.G.: Optimal golf swing kinetics and kinematics. Science and Golf I. Proceedings of the First World Scientific Congress of Golf; pp.3-13 (1990)

Appendix

Table 1. Putting parameters for the putting robot and human subject.

Putting Parameters	Quintic Putting robot	Human Subject
Impact Ball Speed	3mph ± 0.25	3mph ± 0.25
Initial Launch Angle	2° ± 0.5˚	0.75° ± 2.5°
RPM cut or hook spin	0 - 20 rpm	0 – 20 rpm

Table 2. Ball roll characteristics of four different surfaces for the two methods. Data are mean ± SD.

Surface	**Coefficient of Friction (μ)**		
	Mean ± SD	***Range***	***Mean distance to True Roll. (Inches / Meters)***
Robot			
Putt mat	.24 ± .01	.21 - .26	7.03 (.18)
Rubber	.29 ± .02	.27 - .34	6.00 (.15)
MFC	.11 ± .01	.09 - .13	16.77 (.43)
Carpet	.17 ± .01	.15 - .19	10.33 (.26)
Human			
Putt mat	.24 ± .01	.22 – .27	7.35 (.19)
Rubber	.31 ± .03	.28 – .37	5.65 (.14)
MFC	.10 ± .01	.09 – .12	17.59 (.45)
Carpet	.19 ± .01	.17 – .21	9.60 (.24)

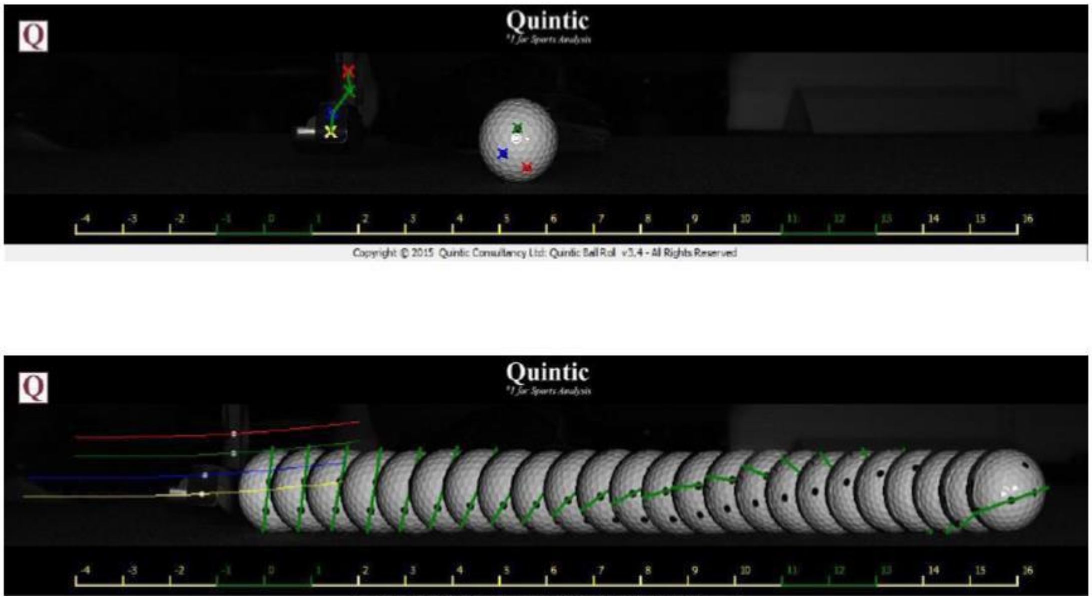

Fig. 1. A visual representation of how the golf ball is tracked during a putt

Fig. 2. Coefficient of kinetic friction (μ) derived from four different surfaces using the two different methods.