International Journal of Golf Science, 2016, 5, 87-97
https://doi.org/10.1123/ijgs.2015-0013

Human Kinetics
ARTICLE

Exploratory Study Investigating Performance Outcomes Between Standard and Anchored Putters

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Both the Royal and Ancient (R&A) and the United States Golf Association (USGA) have announced a ban against the use of anchored putters that went into effect at the start of the 2016 season. However, the benefit of an anchored putter has been debated but never tested. The purpose of this study was to determine if the anchored putter aids players in making more accurate putts. Twenty-four (9 male and 15 female) novice and 14 expert male participants putted with both a standard length putter and a long belly anchored putter 1 m and 4 m away from the hole. Novices produced a shorter back swing and controlled the putter head velocity more accurately with the belly putter compared with the standard putter. Therefore, while long term practice effect is yet to be determined, a short-term benefit of using a belly putter was found.

Keywords: standard putter, belly putter, long putter

Alexander and Kern (2005) reported that putting ability is the single most important determinant of player earnings although Baugher, Day, and Burford (2016) more recently reported that it is no longer true as the courses are getting

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longer and the roughs are getting shorter. Nevertheless, the significance of putting is inarguable as it is responsible for approximately 40–50% of the score in golf. However, most research investigation has focused on the golf swing with few biomechanical studies on putting (e.g., Delphinus & Sayers, 2012; Delay, Nougier, Orliaguet, & Coello, 1997; Neal & Wilson, 1985). In addition, much of putting research has focused on other aspects of the putting stroke itself specifically on the eye-gaze behavior (Campbell & Moran, 2009; Vickers, 2012), the yips (Bell, Skinner, & Fisher, 2009), the effect of ball alignment aid on putting (Shim, Miller, & Lutz, 2012; Stenner & Buckley, 2014), and the effect of focus modes (Munzert, Maurer, & Reiser, 2014; Bell & Hardy, 2009). It was not until recently, that the debate on putting centered around how the putting stroke was produced.

Professional Golf Association (PGA) professionals such as Keegan Bradley (2011 PGA champion), Webb Simpson (2012 U.S. Open champion), Ernie Els (2012 British Open champion), Adam Scott (2013 Masters champion), and 14-year-old Tianlang Guan (youngest player to make a cut at a major) can no longer use a putter that is anchored against a part of their body. The top of the club is usually held against the body with a belly putter, while with the broom-handled long putter the gripping hand usually rests against the chest or chin. On May 21, 2013 both the Royal and Ancient (R&A) and the United States Golf Association (USGA) agreed on signing in Rule 14–1b, a ban against the use of an anchored putter which took effect on January 1, 2016. The Rule 14–1b states, "In making a stroke, the player must not anchor the club, either 'directly' or by use of an 'anchor point.'" The club is anchored "directly" when the player intentionally holds the club or a gripping hand in contact with any part of his/her body with an exception of against a hand or forearm. An anchor point exists when the player intentionally holds a forearm in contact with any part of his/her body.

While anchoring the putter is banned among golf professionals, amateur and recreational players can nevertheless still enjoy its potential benefits. A belly putter is an anchored putter which has a longer shaft than the standard normal length putter which is 33–35 inches long. The controversy surrounding these putters is not about the putters themselves, but rather how they are used. In most cases, they are 'anchored' against the golfer's chin, chest or belly which means that the butt end of the shaft is pressed into the belly (for example) thereby creating a third point of contact with the body (the hands are the other two points). Anecdotally, this anchoring minimizes movement by the wrists and creates a fulcrum for a more pendulum-like stroke (considered to be optimal for sinking putts).

Anchored putters received great attention when players using them started winning major golf tournaments. Keegan Bradley became the first major champion to use a belly putter when he won the 2011 PGA Championship. Then, Webb Simpson won the 2012 US Open Championship and Ernie Els won the 2012 Open Championship (beating Adam Scott by one shot), and they all used longer anchored putters. From very few winners in the history of the game until August 2011, three winners of the next four consecutive majors (Bubba Watson being the exception at the 2012 Masters) used the longer and anchored putter versions. However, the streak ended and there has not been a winner of a major tournament who used an anchored putter since Scott won the 2013 Masters until the ban in 2016.

So, does the anchored putter provide an unfair advantage? There appears to be no statistical or biomechanical evidence to show that longer anchored putters are

more effective than standard non anchored putters. On the 2011 US PGA Tour, only Webb Simpson (ranked 40th) was inside the top 100 best putters and therefore 99 of the best 100 putters used the standard putter. Smith (2013) argued that the belly putter or long putter does not provide an advantage because of its anchoring point. Because the anchored putter is rotating about a different axis than the swinging arms, more degrees of freedom are introduced which is not ideal for a precision task with a relatively limited range of motion.

There is few preexisting scientific literature on the comparisons between the standard and anchored putter. Guadagnoli and Aylsworth (2013) investigated the transfer of learning effect between anchored and standard putters. They developed a technique called 'Challenge Point Framework (CPF)' which can significantly increase transfer effect from one skill to another such as in putting from a standard putter to an anchored putter or vice versa. The key in maximizing efficiency of practice or transfer effect, according to their CPF, is creating a task environment with an optimal level of challenge that is learner specific. This framework is similar to what Lee and Schmidt (2014) have termed 'PaR (Plan-and-Review) Golf' where golf practice that best simulates play on the course (creating a higher level of challenge) would maximize learning.

Among the few biomechanical research investigations on putting, Filmalter's (2012) article published in Golf Magazine may be the only study that directly compared the putting strokes of standard and belly putters. Filmalter compared the two putters among players of various skill levels depending on their handicaps (not including novices) and found few differences between them across skill levels. Filmalter found some exceptions on the putter rotation and added putter loft at impact. Because a belly putter is anchored and allows more pendulum stroke, players tend to rotate the putter head and deloft the face more with the belly putter although this does not necessarily appear to contribute to more successful putts.

The purpose of this study was to determine if anchored putters aid novice players in making less variable and more accurate putts. We believe that keeping the end of the putter fixated on the body allows the putter, hands, arms, and trunk to move together as one unit. Without an anchor, the putter is put at greater risk of moving independent of other involved body segments which can lead to an inconsistent putting stroke, especially for novices. We admit that this assumption is speculative as there is little in the research literature that would support this argument. We hypothesized that anchored putters enhance consistency in putting strokes, as determined through variability measures, which can ultimately increase putting accuracy. We expect the benefit of a belly putter would be found mostly in novices rather than expert players as experts are already experienced standard putter users. Thus, for experts, the emphasis was put more on the transient transfer effect from standard to belly putter.

Methods

Participants

Twenty-four (9 males, 15 females; age = 20.0 ± 1.8 yrs.) novices and 14 (age = 32.7 ± 15.0 yrs.) expert male participants participated in the study. Novices were mostly college students who did not have an established handicap index and have never

played a round of golf except for miniature golf. Experts had an average USGA handicap index (HI) of 4.3 ± 3.1 and some of them have played competitively in high school and/or have played for over 20 years. All experts were standard putter users and all participants were right handed.

Apparatus

The study was conducted indoors on a 15 × 15 m flat artificial green. As shown in Figure 1, SAM PuttLab system was used to measure various kinematic parameters of the putter during the stroke. Special goggles (PLATO) were used to occlude vision immediately after ball impact so participants could not rely on visual feedback to adjust for their next putt. The same standard putter was used with an extension (Belly Putt) attached to create a belly putter so that the two putters were only different in length. However, because of the extension, the belly putter weighed more than the standard putter. Belly putters are generally 17.8 cm longer than a standard putter and the length was adjusted for each participant so that he/she could maintain the same putting posture with an exception of the butt end of the extension resting comfortably against the participant's belly.

Procedure

Before the start of data collection, participants were allowed to warm-up with both types of putters and putt at holes (other than the hole used for testing) to get familiar with the putter and the putting surface. There were two-length putts (4 m and 1 m) and two putting tasks (belly and standard). Participants performed

Figure 1 — Experimental setup.

10 putts for each putting task from each length. Each participant performed 40 putts in total. Both lengths and tasks were counterbalanced and randomized. For novices, brief instruction on the conventional putting grip was given so that they would know how to hold both putters. After each putt, participants were asked to take a step off the putting zone which required them to reestablish the stance so that they treat each trial as a new putt. An acceptable margin of error to make 4 m length putt is ± 0.78 degrees considering the hole diameter of 10.8 cm. With SAM PuttLab system, the average absolute error of 10 successful putts was measured at 0.77 degrees with the putter head speed of 1.57 m/s which caused the ball to travel past the cup located 4 m away and stop within 0.4 m based on the rolling friction of the putting green and the coefficient of restitution between the ball and the putter. The data confirms a straight line putt and validates accuracy of the SAM PuttLab system in the measurement of the putter angle.

Data Analysis

SAM PuttLab system measures over 50 variables from the putter in each stroke. Following further discussion with a few PGA professional golf coaches, several important kinematic parameters in putting were identified. Two temporal parameters (back swing time and forward swing time), two length parameters (back swing length and forward swing length), and five parameters at impact (putter velocity, putter head angle, putter swing path, putter contact point, and ball direction) were selected for further analyses. We also included the percentage of putt success rate (percentage of putts holed) in the analysis. Therefore, the mean and variability (within-subject standard deviation) of 10 parameters were measured, and on each parameter, a 2 (Distance: short, long) × 2 (Putter: belly × standard) ANOVA with repeated measures on both factors was performed. Variability measure was used to determine players' consistency on the putting stroke. Experts and novices were analyzed separately because the experts' results would skew the data as they were more familiar with the standard putter compared with the novices. Thus, we expected experts to putt more consistent with higher success rate using the standard putter. The focus was on their adaptability to the belly putter. Means were considered significantly different when the probability of a type I error was .05 or less. We used Mauchly's test for sphericity and if the sphericity assumption was violated, Huynh-Feldt corrections for the p-values were reported. Partial eta-squared (η_p^2) values were computed to determine the proportion of total variability attributable to each factor or combination of factors.

Results

After completion of the study, participants were asked for their preference by considering which putter made them feel more comfortable and/or assisted putting. Sixteen novices reported a preference for the belly putter while eight novices preferred the standard putter. All experts preferred the standard putter.

There were apparent differences in temporal and length parameters between short and long distance putts among both novices and experts, and participants were more consistent on short putts compared with long putts as expected. When comparing belly and standard putter for novices, some differences were found

during back swing and at impact. On a 2-way (Distance × Putter) ANOVA with repeated measures on both factors, putter back swing length showed a significant effect on distance, $F(1, 23) = 87.68$, $p < .01$, $\eta_p^2 = .79$, and putter, $F(1, 23) = 8.37$, $p < .01$, $\eta_p^2 = .27$, but no interaction ($p > .05$). Similarly, putter velocity at impact showed a significant effect on distance, $F(1, 23) = 320.00$, $p < .01$, $\eta_p^2 = .93$, and putter, $F(1, 23) = 12.96$, $p < .01$, $\eta_p^2 = .36$, but no interaction ($p > .05$). Putter contact point showed neither effect on distance nor interaction ($ps > .05$) but showed an effect on putter, $F(1, 23) = 13.23$, $p < .01$. As shown in Table 1, novices produced a greater back swing length and struck the ball with greater putter head velocity using the standard length putter compared with the belly putter. Putter contact point of

Table 1 Mean Measure of 10 Parameters Using Belly and Standard Putter in Short (1 m) and Long (4 m) Distance

	Length			
	Short		Long	
Parameters	Belly	Standard	Belly	Standard
		Novice		
Back Swing Time (msec)	578.0	580.9	644.8	627.0
Forward Swing Time (msec)	629.7	629.6	644.9	635.8
Back Swing Length (cm) *	14.9	15.3	23.4	25.7
Forward Swing Length (cm)	33.5	35.1	63.4	64.3
Putter Velocity (m/s) *	0.89	0.93	1.67	1.73
Putter Head Angle (degrees)	1.1	1.0	1.6	2.0
Putter Swing Path (degrees)	-0.3	-0.8	-0.1	-0.2
Putter Contact Point (mm) *	1.1	-0.7	3.4	-0.2
Ball Direction (degrees)	0.9	0.7	1.4	1.7
Putt Success Rate (%)	56.3	52.5	17.1	10.0
		Expert		
Back Swing Time (msec)	623.5	605.2	714.7	710.1
Forward Swing Time (msec)	844.9	853.4	915.4	900.0
Back Swing Length (cm)	14.4	13.9	23.7	24.0
Forward Swing Length (cm)	41.7	41.3	76.9	73.2
Putter Velocity (m/s)	0.87	0.85	1.58	1.57
Putter Head Angle (degrees)	0.9	1.1	0.1	0.23
Putter Swing Path (degrees)	-0.3	-0.4	-1.6	-2.0
Putter Contact Point (mm)	4.6	6.2	3.7	5.1
Ball Direction (degrees)	0.7	0.9	-0.1	-0.1
Putt Success Rate (%) #	80.0	71.7	13.3	32.5

Note. * significant effect on putter ($p < .05$). # significant interaction between putter and distance ($p < .05$)

belly putter was further away from the center than standard putter. Despite failing to reach significance on success rate of putts (p = .075), novices demonstrated a higher percentage of success rate with the belly putter in both distances.

On the mean measures of the parameters for experts, no effect was found (p > .05) with an exception on success putt rate with effects on distance, $F(1, 11) = 25.63$, $p < .01$, $\eta_p^2 = .70$, and interaction, $F(1, 11) = 7.22$, $p < .05$, $\eta_p^2 = .40$, but no effect for putter ($p > .05$). Interestingly, experts' success rate was almost 10% higher with belly putter in short distance but almost 20% lower in long distance (See Figure 2).

Regarding the variability of back swing time, main effect was found for putter, $F(1, 23) = 10.96$, $p < .05$, $\eta_p^2 = .34$, but showed neither effect for distance nor interaction ($p > .05$). As shown in Table 2, novices demonstrated more consistent back swing time with the standard putter (45.1 ms) than the belly putter (55.8 ms). Experts generally showed more effects on the variability in swing time and swing length, and while there was no interaction of putter and distance found for novices, experts demonstrated some interactions. Variability of back swing time showed effects on putter, $F(1, 11) = 12.48$, $p < .01$, $\eta_p^2 = .53$, and interaction, $F(1, 11) = 7.47$, $p < .05$, $\eta_p^2 = .41$, but no effect on distance ($p > .05$). On the other hand, variability of forward swing length showed effects on distance, $F(1, 11) = 35.89$, $p < .01$, $\eta_p^2 = .77$, and interaction, $F(1, 11) = 5.68$, $p < .05$, $\eta_p^2 = .34$, but no effect for putter ($p > .05$).

As shown in Figure 3, while experts back swing time was more variable using the belly putter in short distance putts, their forward swing length was more variable using the belly putter in long distance putts. Variability of forward swing length showed a similar interaction between distance and putter as the interaction found in putt success rate. A greater variability of forward swing length coincided with less success rate and vice versa particularly in long distance. However, as the mean and variability of putter velocity at impact, which primarily determines how far the ball rolls, were not different between the two putters, it may be that experts' inconsistency of the forward swing length in long putts occurred during follow-through after the impact.

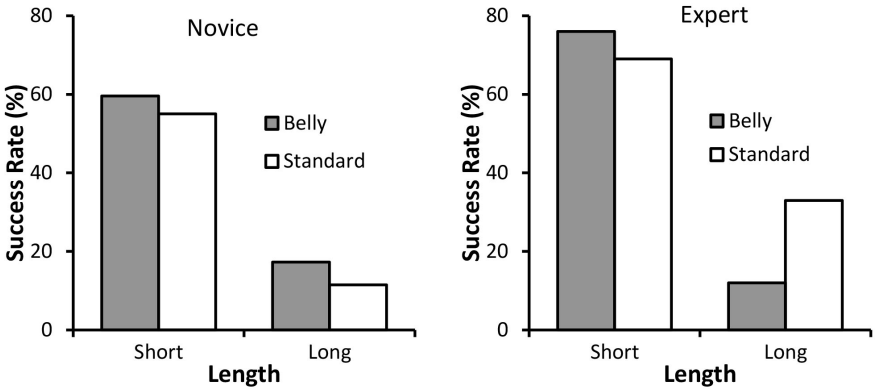

Figure 2 — Success rate of novices and experts in belly and standard putter of short and long distance.

Table 2 Variability Measure of 9 Parameters Using Belly and Standard Putter in Short (1 m) and Long (4 m) Distance

	Length			
	Short		Long	
Parameters	Belly	Standard	Belly	Standard
		Novice		
Back Swing Time (msec) *	56.7	45.1	54.9	45.1
Forward Swing Time (msec)	65.3	56.0	58.0	48.9
Back Swing Length (cm)	2.4	2.7	3.6	3.6
Forward Swing Length (cm)	4.1	4.3	7.3	7.6
Putter Velocity (m/s)	0.1	0.1	0.2	0.2
Putter Head Angle (degrees)	1.5	1.6	1.9	2.2
Putter Swing Path (degrees)	2.5	2.4	2.5	2.3
Putter Contact Point (mm)	5.4	6.0	7.6	7.4
Ball Direction (degrees)	1.4	1.5	1.7	1.9
		Expert		
Back Swing Time (msec) #	45.6	33.0	37.7	38.0
Forward Swing Time (msec)	72.3	69.2	87.8	75.0
Back Swing Length (cm)	1.1	1.3	1.8	1.5
Forward Swing Length (cm) #	3.2	3.5	5.9	4.8
Putter Velocity (m/s)	0.04	0.04	0.08	0.08
Putter Head Angle (degrees)	0.8	0.8	1.0	1.0
Putter Swing Path (degrees)	1.8	1.4	1.4	1.3
Putter Contact Point (mm)	3.0	2.9	3.7	3.3
Ball Direction (degrees)	0.8	0.7	0.9	1.0

Note. * significant effect on putter ($p < .05$). # significant interaction between putter and distance ($p < .05$)

Discussion

Using a belly putter overall did not provide evidence of an advantage over the standard putter in making more successful putts. However, results may be regarded promising in that a transition from standard to belly putter seems positive and beneficial to novice players. Novices showed a trend of making more putts (Figure 2) and their kinematic data showed more favorable results with the belly putter, and two out of three novices expressed a preference for the belly putter over the standard putter. Despite some favorable results for the standard putter among experts, in the key determinants of ball speed and direction (i.e., putter velocity, putter angle at impact, putter swing path), there were no differences between the two putters which shows a strong potential for an immediate transfer effect to the belly putter.

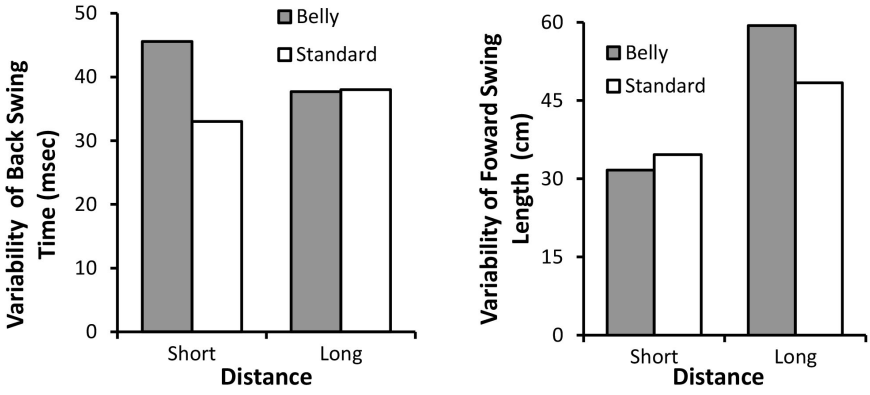

Figure 3 — Variability of back swing time and variability of forward swing length of experts in belly and standard putter of short and long distance.

Having the proximal end of putter anchored against the belly should assist in producing a smoother pendulum motion compared with without an anchor as the axis of rotation is fixed and stable. Though just failing to reach statistical significance (p = .075), novices' mean success rate for belly putter (36.7%) was 5.4% higher than standard putter (31.3%). For novices who may average three or more putts for each hole, 7.1% higher success rate can be equivalent to reducing 3–4 strokes in a round of golf. Along with the results on putting success rate, other kinematic data show more favorable results with the belly putter. Novices produced more compact back swing with the belly putter. With the standard putter, their back swing was longer and faster, and because as the putter, arms, and body move independently, there is possibly greater room for increased degrees of freedom of movement. In addition, as anchored putters are longer, they weigh more which might contribute to a shorter back swing. On the putting green where the participants were tested, we measured how much putter speed is required to strike and stop the ball within 0.2 m and 0.4 m of the hole located 1 m and 4 m away, respectively. The putter had to travel approximately 0.85 m/s and 1.57 m/s for 1 m and 4 m holes respectively, which speeds are similar to what experts did as shown in Table 1. Novices produced significantly slower putter velocities with the belly putter that matched more closely to the required putter velocities in both distances. Therefore, although we did not directly measure the ball-to-hole distance as some putts would go in, novices with the belly putter would have putted closer to the hole in distance which is critical in putting to avoid a risk of three or more putts. With much greater putter velocity of the standard putter, novices would hit the ball long past the cup if missed which would lead to a distant second putt. Among 10 parameters examined, only one showed a favorable result for the standard putter in that novices' back swing time was more consistent with the standard putter than the belly putter. However, the back swing phase is not as important as the forward swing phase as it does not directly affect the putter head speed at impact. It must also be noted that, due to unfamiliarity with the belly putter, we observed that novices awkwardly initiated the putting stroke which may account for such inconsistency.

Surprisingly, experts, despite having numerous years of experience with the standard putter, showed few favorable results for the standard putter. Perhaps as Guadagnoli and Aylsworth (2013) have argued, although they did not provide direct evidence and it is more speculative, the transition from standard to belly putter may be easier than vice versa. Experts had more variability in their back swing time with the belly putter but it is not a critical determinant of ball speed as forward swing phase is more important. Experts' forward swing length was also more variable with the belly putter but the length did not impact the putter velocity. Experts had lower success rate with the belly putter in long putts but higher rate in short putts. It is generally believed among golf coaches and players that anchored putters assist more with short putts than long putts as it is more difficult to make a long putting stroke with the anchored putter. With minimal time of practice with the belly putter, it would be difficult to find any transfer effect but, in the future, it would be worthwhile to examine how quickly experts of standard putter could adapt to an anchored putter after a longer period of practice.

There are many types of grips used to putt, and we suspect that players experiment with various types trying to find the one that would help putt more accurately. Some well-known grips include the reverse (cross-handed) grip and the claw grip with different variations. Before the ban, players experimented with anchoring the end of a putter against the belly or the chest. Some have gone farther experimenting with other ways to anchor the putter. For example, PGA professional Matt Kuchar rests the putter grip along the forearm to keep the arm and putter moving in one unit and to prevent wrist action. After the adoption of Rule 14–1b, Bernhard Langer anchors his long putter during practice but detaches it during the actual stroke.

As the results show, we feel strongly that having one end of the putter securely fixed to the belly or the chest stabilizes the putter to move more smoothly and consistently. However, learning the correct way of using the belly putter can be difficult and may require more time to learn because keeping constant pressure against the belly or chest can be a challenge. In this study, we witnessed many novices struggling to keep the putter secured on the belly. Some novices were unsure where on the trunk the end of the putter should be anchored. If the pressure is lost and becomes loose during the stroke, the putter can be thrown off of its regular path. Despite the challenges, using a belly putter showed positive benefits even with minimal practice and with further practice, more benefits may become apparent.

So far, there is no empirical data to suggest that more successful putts can be made with anchored belly putters. This study is a first attempt to investigate the advantage and, although further investigation is required to determine its effectiveness after a long period of practice, the belly putter showed more favorable results for novice players especially on key factors of keeping the back swing more compact and controlling the putter head speed. Belly putters also seemed to have a psychological benefit in that novices preferred the belly putter over the standard putter. Despite the ban by the PGA, we believe that amateurs will have more success with using the anchored putter.

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