Putting movement and performance outcome using standard, belly and long putters
Authors

Ian A Sherwin\(^1\) and Ian C Kenny\(^1\)

Affiliations

\(^1\)Biomechanics Research Unit, University of Limerick, Ireland

Corresponding Author:

Ian C. Kenny, Biomechanics Research Unit, Department of Physical Education and Sport Sciences, University of Limerick, Limerick, Ireland.

Email: ian.kenny@ul.ie
Abstract

In golf, play on the green has a large impact on final score and a great amount of time is spent on coaching and practice greens to improve putting performance. The study purpose was to measure putting outcome performance when different length putters were used with an anchoring mechanism. Seventy-two skilled golfers each executed a total of 60 putts using standard, belly and long putters from two distances. Putting mechanics were assessed using SAM PuttLab™. From 1.83 m (6 ft) participants holed 80.3% of putts with a standard length putter, dropping to 78.6% and 75.3% for belly and long-handled putters. At 3.66 m (12 ft) participants holed 51.7% of putts with a standard length putter, and 50.8% and 46.9% for belly and long-handled putters. Shot performance showed no significant differences between or within clubs. There were significant (p<0.05) but small effect size between-club differences for swing time, putter head rotation and putter face impact spot. Results show that while anchoring may reduce putter head rotation it does not prevent rotation. It has been ascertained for a large cohort of different handicap golfers not accustomed to using longer putters, that using an anchored putter will not necessarily provide a scoring advantage over using a standard putter without an anchoring system. Practice may better focus on the individual golfer’s specific technical weaknesses identified by the performer or by a coach.

Keywords

Golf, performance, putter length, putting
Introduction

The aim of the putting stroke is to start the ball with the intended speed on the intended line [1]. There has been significant research carried out on putting styles, equipment and mechanics [2-4], however, with new technology being submitted to golf’s governing bodies for assessment on a daily basis there is a need for continued research. Previous studies have tended to focus on professional golfers which do not represent the wider golfing population. Figures from the USGA Handicap Index [5] show that less than 11% of golfers fall into category 1 (Handicap ≤5) whereas over 52% fall into categories 3 and 4 (handicaps 13-20 and 21-28 respectively). Previous studies [1,6-7] have also focused on the mechanics and overall kinematics of the putt, with few previous studies [8, 9] dealing with the performance outcome, and there is little evidence to date of whether putter selection changes performance.

From the time that Billy Casper began using an anchoring mechanism by placing his left hand against his left leg in 1956 there has been a variety of methods employed by professional and amateur golfers to grip the putter [10]. In 1989 Mark Lye became the first player to use the long putter on the USPGA Tour and throughout the early years of the 21st century numerous players experimented with long and belly putters. For the purpose of this study we considered a long putter to be one in which the butt of the grip is at least as high as the golfer’s sternum, when the golfer is standing erect and the putter is positioned in an address orientation. Similarly, a belly putter, for the purpose of this study is considered to be one in which the butt of the grip is at least as high
as the golfer’s navel when the golfer is standing erect and the putter is positioned in an address orientation.

A statement [11] (Associated Press, 28th November 2012) by both governing bodies of golf the USGA and the R&A Rules Ltd. introduced the ban on using an anchoring mechanism while putting but made it very clear that the ban did not apply to the equipment, only the manner in which it is being used. The anchoring mechanism ban came into effect from 1st January 2016. The rule change introduced Rule 14-1(b) which reads, "In making a stroke, the player must not anchor the club, either ‘directly’ or by use of an ‘anchor point’ (Figure 1). There were no empirical data offered during the statement to suggest that golfers who anchor the putter while putting found the task easier or improved performance. A good technique is crucial to create confidence in this area of the game and the ability to create a stable posture and pivot point is essential if the putter is to be returned consistently from the point of address to the moment of impact [12]. How this is executed varies from golfer to golfer but the general consensus in the literature is that the need for ‘squareness’ (putter face angle) is a fundamental requirement for getting the ball to go in the intended direction [1,13-15].

In MacKenzie et al. [7] the authors determined that ‘a face angle of approximately 0.6° (from square to the target line) was necessary for the roboticised putting machine to start missing putts from 4 m’. The time of contact is extremely short and varies depending on the length of putt but is approximately half a millisecond. Indeed, Cochran and Stobbs [15] state that the putter head behaves as though it were disconnected from the putter shaft while actually in contact with the ball.
In one of the most rigorous putting kinematics studies published to date, Karlsen et al. [6] assessed the importance of the putting stroke for direction consistency, using SAM PuttLab ultrasound motion analysis to examine 3-4
metre (9.8-13.1 ft) putts of 71 elite players. They found that face angle was the
most important factor (80%) in determining stroke direction consistency,
followed by putter path (17%) and impact point (3%). They concluded that the
putting stroke of elite golfers has a relatively minor influence on direction
consistency. Delay et al. [4] examined movement control in putting and showed
that the movement of putting consists primarily in specifying the amplitude of
the backswing (BS) as a function of the distance of the target. Expert golfers
(professional or <5 handicap) increased backswing and downswing amplitude
and velocity with increasing putt distance. These findings were supported by
Sim and Kim [16] who demonstrated differences in relative timing, relative
amplitude and velocity, but no difference in time-to-contact between novice and
expert golfers. Sim and Kim [16] showed that experts achieved higher accuracy
with lower impact velocity than novices. Furthermore, while the putter ‘sweet
spot’ is the point on the club face where contact is considered the most solid,
analysis by Mackenzie et al. [7], found that horizontal putter head impact spot
has least influence on the outcome of a putt.

The importance of the stroke was questioned in research by Sones et al.
[10] across a variety of handicaps on a 3.05 m (10 ft) putt using SAM PuttLab™
to measure 18 different parameters of the putting stroke testing a belly putter in
comparison to a standard length putter. In this non-peer reviewed research
Sones et al. [10] found that players of all levels rotate the putter head with
higher handicap players rotating more than lower handicap players. Anchoring
the putter may limit the amount of rotation but it will not stop a poor golfer from
over-rotating the putter head in relation to the line of the putt; a likely reaction to
the extra club head weight and longer stroke length, despite the limitation of
wrist break magnitude (flexion-extension) that anchoring a club may control [16].

Gwyn & Patch [2] compared two putting styles using the standard length putter (86.3 cm, 34") to the long putter (132.08 cm, 52") and showed that no significant difference existed between the putting styles with respect to final ball distance from the hole on a first putt from a range of putt distances between 0.60 m (2 ft) and 15.24 m (50 ft). They noted that the standard length putter may not be the best for performance outcome for all beginning golfers and that using a long putter may be as effective. Reasons why skilled golfers have been reported to move from standard length putters to belly or long putters has not been well examined. Of the limited work carried out, Smith et al. [18] reported that golfers have changed putters to try to combat ‘yips’, a psychoneuromuscular impediment affecting execution of the stroke manifesting in jerks, tremors and ‘freezing’. Changing putter may offer access to an alternative motor program for some players but requires careful consideration by the golfer and their coach. While researchers have started to explore the kinematic features of the putting stroke that have the greatest influence on stroke direction consistency, researchers have yet to investigate if the type of putter used by golfers influences movement and performance proficiency. This line of enquiry is of particular relevance given the recent rule change enacted by the USGA and the R&A Rules Ltd..

The aim of the current study was to examine putting outcome performance and establish if there is a performance advantage to be gained by using an anchored putter. This study directly measured shot accuracy with

8
different putters used by different handicap categories of golfers, both male and female.

Method

Participants and Equipment

For this non-blinded, non-randomised study inclusion criteria requested that participants played at least one round of golf per week and had a current Category 1 to Category 4 golf handicap. Each participant’s handicap category was determined according to the CONGU guidelines as stipulated in the CONGU Handicap Manual [19]. Both male and female right handed participants were included and due to the large sample size, testing took place over a number of days. Participants were excluded if they did not meet the specified inclusion criteria or if they suffered from any injury preventing them from playing golf in the three months leading up to the study. Speed of the greens, timing of treatment of the greens and close monitoring of the weather forecast were some of the measures included to ensure an ecologically valid study.

Seventy-two healthy golfers (62 male, 10 female) participated in this study ranging in age from 15 to 75. All participants were recruited through club notice boards, weekly newsletters and word of mouth. The current study did not examine skill level performance differences. Approval for the use of human participants was obtained from the university review board of research compliance. Participants were informed of the experimental risks and signed an informed consent document before the investigation.

All putters and balls used in the study were of premium standard and supplied by Titleist Golf™. The putters were part of the Scotty Cameron™
range of Select GoLo, Select GoLo Mid and Select Long (Big Sur) Putters. The specifications for each of the putters are listed in Table 1.

***TABLE 1 NEAR HERE***

The current study was conducted outdoors thus creating an ecologically sound natural environment for participants. Care was taken to ensure where possible that test conditions were similar from day to day. Testing was not carried out on days where it was raining or had rained as this may have affected the speed of the green. At the time of year of testing (Autumn) growth on the green was not a factor from the time the green was prepared each morning to the late afternoon when testing finished for the day. The green was triple cut to 3 mm. A Stimpmeter™ reading was taken every morning and afternoon with no significant difference recorded. The reading from the Stimpmeter was 9.5 – 10.0. A spirit level was used to ensure there was no slope on the putt line and a measuring tape was used to measure out 1.83 m (6 ft) and 3.66 m (12 ft) putt distances. Both distances were identified by coloured spray markers to ensure the ball was placed on the same spot for every trial. Two other points were measured at 0.5 m perpendicular to the 1.83 m (6 ft) and 3.66 m (12 ft) markers on the putt line so that a SAM PuttLab™ base unit could be accurately positioned for each participant.

Putting parameters were recorded with a three-dimensional kinematic system (SAM PuttLab™, Science and Motion GmbH, Mainz, Germany [6,9,19,20]. A triplet with three 70 Hz ultrasound transmitters, which emitted signals to a base unit, was attached to the putter. The base unit was calibrated
according to the user manual and data were processed and analysed using the
SAM™ Version 2010 software. The information from the base unit was relayed
to a laptop set up on the edge of the putting green.

Experimental Procedures

The putt was straight and flat and thus did not require the subjects to read the
green or allow for any break or movement in their putts. Seventy one of the
seventy two participants were habitual standard length putter users. Each
participant was allowed to warm-up in a self-selected manner with a
familiarisation period of 10 minutes. This time was given for the participant to
become comfortable with the belly and long putters and to try out a number of
different grip orientations. No tuition was given. The participants then performed
a number of practice trials (approximately 7-10) for each putter from each
distance. Calibration was achieved by lining up putts and as required using a
laser device to align the putter head with the hole. This provided a relative
calibrated start position for all participants, whereby this study could assess
how putting mechanics for the different clubs affected outcome, not influenced
by participants’ ability to aim. The laser was held over the mid-point of the
putter-head and fixed on a marker placed 0.3 m beyond the mid-point of the
hole. Each participant was then asked to perform 10 putts with each club from
both distances. The order in which the putters were used was random as was
the order from which distance the participant started. However, once the testing
had started the participant completed all putts (30) from that distance and then
completed the remaining putts (30) from the other distance. It was observed
that all 72 golfers adopted an anchor to the belly and to the chest with the belly and long putters respectively.

Data Analysis

Measures of backswing time (BSTIME), forward swing time from beginning of the forward swing to impact with the ball (TIMP), putter face angle at impact (FACEIMP), putter face rotation angle from the beginning of the forward swing to impact (ROTIMP) and horizontal putter impact spot (SPOTIMP) were recorded (Figure 2). In addition performance outcome measures binary data (missed putt = 0, holed putt = 1) for successful and unsuccessful putts were amalgamated in tabular form using MS™ Excel v9.0 before being transferred into SPSS™. Ball final distance from the hole was not measured in this outdoor setting. Descriptive statistics were calculated relating to the central tendency of the measures namely mean, standard deviation and coefficient of variation where appropriate for all measures. Within-group differences were compared using a one-way multivariate analysis of variance (one-way MANOVA). Between groups were compared using a two-way repeated measures ANOVA. A Bonferroni post-hoc test was applied to any measures that showed significant variance. Homogeneity of variance was evaluated using Mauchly’s Test of Sphericity and when violated, the Greenhouse-Geisser adjustment was used. To determine the magnitude of between-group change in variables, a Cohen’s d effect size test was performed. The level of significance was set at P ≤ 0.05. SPSS Statistics 22 software (IBM Corp, Version 22.0. Armonk, NY) was used for all statistical calculations.
Figure 2. Representative a.putter face impact spot location (SPOTIMP), b.putter face rotation angle to impact (ROTIMP) and c.putter face angle at impact (FACEIMP).

Results

Shown in Table 2 are the total number of putts holed and the percentage of successful putts with each putter, for all participants, for short 1.83 m (6 ft) putts, and for longer 3.66 m (12 ft) putts. As a group, participants were found to be most successful with the standard length putter from this distance. There was no significant difference between clubs. Figures 3 and 4 present between-group shot performance variability data for all 72 participants for each putter for the short distance (Figure 3) and longer distance (Figure 4).

***TABLE 2 NEAR HERE***
Figure 3. Percentage of successful putts by all 72 participants using standard, belly and long putting clubs with an anchoring mechanism from 1.83 m (6 ft).

Figure 4. Percentage of successful putts by all 72 participants using standard, belly and long putting clubs with an anchoring mechanism from 3.66 m (12 ft).
Table 3 illustrates the mean and standard deviation for all participants using the three different putters from both distances, 1.83 m (6 ft) and 3.66 m (12 ft) for backswing time (BSTIME), forward swing time (TIMP), putter face angle at impact (FACEIMP), putter face rotation from the beginning of the forward swing to impact (ROTIMP) and horizontal impact spot distance from putter face centre (SPOTIMP). There was no significant club difference for FACEIMP for any of the putters. However significant differences were observed between clubs for all the other variables with trivial to small effect size ($d = 0.03-0.29$, $p<0.05$). Coefficient of variation for appropriate measures not affected by relative positive and negative data range showed consistency with timing, and decreased variability for ROTIMP for longer clubs.

***TABLE 3 NEAR HERE***

Discussion

The purpose of this study was to examine putting outcome performance and establish if there is a performance advantage to be gained by using an anchored putter. No significant club differences existed for shot performance. When considering the results there was a significant difference for a number of input variables tested. This was most notable for backswing time (BSTIME), forward swing time (TIMP), putter face rotation from the beginning of the forward swing to impact (ROTIMP) and horizontal impact spot (SPOTIMP). Sones et al. [10] found that using an anchored putter will not change your stroke and that the stroke performance with a standard putter will be the same as that with a belly putter and vice versa. Overall, results from the current study would
suggest that is not the case, however, when the data are separated by distance there was no difference in backswing time between the standard putter and belly putter on a 1.83 m (6 ft) putt but there was a difference on a longer putt of 3.66 m (12 ft) which would agree with the findings in Sones et al. [10]. The same applies to the time to impact for forward swing where the notable difference was in the longer putt. Interestingly, on average all golfers presented a swing tempo of 0.460 consistently, regardless of which putter they used, which is a more meaningful measure of timing for the player and coach considering the natural increase in club swing arc for longer putting clubs.

Feedback during and after the testing from some of the participants suggested that they had a perception of having to adjust their putting stroke during the testing due to the different putters. This feedback was generally given by participants from low handicap golfers (LHG, ≤12 handicap) specifically in relation to using a heavier putter than that with which they were accustomed. This focus on technical adjustment has been reported previously by Toner and Moran [22] which showed that although golfers may have adjusted their stroke (eg. slowed BSTIME) the disruption to the timing had little influence on expert golfers’ putting proficiency. The adjustment to putting stroke in the current study may be indicative of conscious control, supported by slower backswing times both as putt distance and club length increased. Delay et al. [4] noted that skilled golfers hit the ball during the acceleration phase of the forward swing which allowed for a more precise contact with the ball. This meant that the ball was more likely to roll along the desired line rather than slide with a slight backwards rotation. The latter movement will mean the ball may not reach the target and it may also be deviated from the intended path.
The intention of the putting stroke is to return the clubface to square to the putt line from the start of the movement through the backswing and forward swing to impact. The results of the current study showed that there was a significant difference in ROTIMP and SPOTIMP between the standard and belly putter and the belly and long putter. Putter head path rotation through impact (ROTIMP) decreased as club length increased. Sones et al. [10] argue that anchoring the putter may limit putter head rotation via wrist control but will not stop a poor putter from aiming incorrectly, rotating due to other body movements, and starting the ball off the intended putt line. Current findings also agree with Karlsen et al. [6] who reported that face angle was the most important factor (80%) in determining stroke direction consistency, denoted by significant difference in putter head path rotation affecting face angle through impact between all club lengths in the current study, concomitantly with decreased outcome performance for longer clubs.

Shot Performance

In the outdoor setting, the current study focused on ecologically valid putting success; it did not assess ball finish distance from the hole therefore shots finishing short but in line with the hole were treated as a ‘miss’ the same as shots left and right of the hole. Participants in the current study were successful 78.06% of the time from 1.83 m (6 ft) irrespective of which putter they used. In the case of the shorter putt (1.83 m, 6 ft) players were more successful with the standard putter (51.7%) than the other two putters, 50.8% and 49.6% for the belly and long putters respectively. Interestingly, individual performance data displayed in Figures 3 and 4 show that some participants did perform better with the long putting club but as a cohort participants performed
best with the standard putter. Fitzpatrick and Anderson [24] have suggested that improved contact between the ball and the clubface may improve putting ability, a point which Delay et al. [4] found is developed by skilled golfers through practice. Not only do golfers with a lower golf handicap practice more often, their practice through lessons was more deliberate, a concept outlined by Ericsson, Krampe and Tesch-Romer [25] where not only was it important to practice but to achieve expert performance the practice has to address specific technical weaknesses identified by the performer through self-regulation or by a coach.

**Conclusion**

It has been ascertained for a large cohort of different handicap golfers not accustomed to using longer putters that using an anchored putter will not necessarily provide a scoring advantage over using a standard putter without an anchoring system. All trials showed more successful putts with the standard length putter. This study tested seventy two golfers on a one-off test and no training or tuition was given to the participants. Further study is needed to test what effect more club familiarisation time or a training programme may have on all golfers. Putts performed under more pressurised conditions such as with an audience or in competition would also be worthy of research, particularly for yips-affected golfers. Practice may better focus on the individual golfer’s specific technical weaknesses identified by the performer or by a coach. Experimenting with different types of putter and grips would be useful in finding a putting method and style that suits each individual golfer. Results showed that all golfers, regardless of which putter used, compensated for changes in putter
face impact location and rotation angle with very consistent swing tempo and putter face angle at impact. It would be very interesting if future studies could examine how those who are used to using a belly or long putter would fare when they are compelled by the new rule change, to dispense with their anchoring mechanism.

References


### Table 1. Technical specifications of the putters used in the study

<table>
<thead>
<tr>
<th>Putter</th>
<th>Loft (°)</th>
<th>Lie (°)</th>
<th>Length (m / inch)</th>
<th>Total mass (kg)</th>
<th>Neck</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>4</td>
<td>71</td>
<td>0.887 (34)</td>
<td>0.55</td>
<td>Single Bend</td>
</tr>
<tr>
<td>Belly</td>
<td>4</td>
<td>71</td>
<td>1.092 (43)</td>
<td>0.70</td>
<td>Single Bend</td>
</tr>
<tr>
<td>Long</td>
<td>4</td>
<td>79</td>
<td>1.321 (52)</td>
<td>0.85</td>
<td>Double Bend</td>
</tr>
</tbody>
</table>

### Table 2. Performance outcome scores for all participants from 1.83 m (6 ft) and 3.66 m (12 ft) with three different putting clubs

<table>
<thead>
<tr>
<th>All participants from 1.83 m (6 ft)</th>
<th>TOTAL</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total successful putts with standard putter out of 720</td>
<td>578</td>
<td>80.3</td>
</tr>
<tr>
<td>Total successful putts with belly putter out of 720</td>
<td>566</td>
<td>78.6</td>
</tr>
<tr>
<td>Total successful putts with long handled putter out of 720</td>
<td>542</td>
<td>75.3</td>
</tr>
<tr>
<td>Total successful putts out of 2160</td>
<td>1686</td>
<td>78.1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>All participants from 3.66 m (12 ft)</th>
<th>TOTAL</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total successful putts with standard putter out of 720</td>
<td>372</td>
<td>51.7</td>
</tr>
<tr>
<td>Total successful putts with belly putter out of 720</td>
<td>366</td>
<td>50.8</td>
</tr>
<tr>
<td>Total successful putts with long handled putter out of 720</td>
<td>338</td>
<td>46.9</td>
</tr>
<tr>
<td>Total Successful Putts out of 2160</td>
<td>1076</td>
<td>49.8</td>
</tr>
</tbody>
</table>
Table 3. Descriptive measures of mean ± SD (coefficient of variation CV % where appropriate) for three putting clubs at two shot distances

<table>
<thead>
<tr>
<th>Putter</th>
<th>BSTIME (ms)</th>
<th>TIMP (ms)</th>
<th>FACEIMP (°)</th>
<th>ROTIMP (°/sec)</th>
<th>SPOTIMP (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>STANDARD</td>
<td>604.12</td>
<td>277.7</td>
<td>0.23</td>
<td>4.9</td>
<td>1.03</td>
</tr>
<tr>
<td></td>
<td>± 135.87 a</td>
<td>± 59.89 b</td>
<td>± 3.37</td>
<td>± 3.04 d</td>
<td>± 8.44 a</td>
</tr>
<tr>
<td></td>
<td>(22.5)</td>
<td>(21.6)</td>
<td>(21.5)</td>
<td>(62.0)</td>
<td></td>
</tr>
<tr>
<td>BELLY</td>
<td>621.29</td>
<td>283.02</td>
<td>0.25</td>
<td>4.96</td>
<td>-0.25</td>
</tr>
<tr>
<td></td>
<td>± 137.28 a</td>
<td>± 60.71 c</td>
<td>± 2.9</td>
<td>± 2.83 d</td>
<td>± 8.72 a</td>
</tr>
<tr>
<td></td>
<td>(22.1)</td>
<td>(21.5)</td>
<td></td>
<td>(57.1)</td>
<td></td>
</tr>
<tr>
<td>LONG</td>
<td>634.04</td>
<td>290.55</td>
<td>0.33</td>
<td>4.33</td>
<td>1.09</td>
</tr>
<tr>
<td></td>
<td>± 126.52 a</td>
<td>± 62.34 b</td>
<td>± 3.06</td>
<td>± 2.52 d</td>
<td>± 8.66 a</td>
</tr>
<tr>
<td></td>
<td>(20.0)</td>
<td>(21.5)</td>
<td></td>
<td>(58.2)</td>
<td></td>
</tr>
<tr>
<td>STANDARD</td>
<td>590.00 b</td>
<td>277.72</td>
<td>0.29</td>
<td>4.36</td>
<td>2.11</td>
</tr>
<tr>
<td>1.83 m</td>
<td>± 139.70 b</td>
<td>± 62.03 b</td>
<td>± 3.31</td>
<td>± 2.58 b</td>
<td>± 6.72 f</td>
</tr>
<tr>
<td></td>
<td>(23.7)</td>
<td>(22.3)</td>
<td></td>
<td>(59.1)</td>
<td></td>
</tr>
<tr>
<td>BELLY</td>
<td>599.25</td>
<td>279.73</td>
<td>0.44</td>
<td>4.22</td>
<td>-0.07</td>
</tr>
<tr>
<td>1.83 m</td>
<td>± 135.83 b</td>
<td>± 63.55 c</td>
<td>± 2.89</td>
<td>± 2.50 c</td>
<td>± 8.29 f</td>
</tr>
<tr>
<td></td>
<td>(22.7)</td>
<td>(22.7)</td>
<td></td>
<td>(59.2)</td>
<td></td>
</tr>
<tr>
<td>LONG</td>
<td>609.93</td>
<td>290.46</td>
<td>0.60</td>
<td>3.74</td>
<td>1.03</td>
</tr>
<tr>
<td>1.83 m</td>
<td>± 126.39 b</td>
<td>± 69.89 b c</td>
<td>± 3.17</td>
<td>± 2.16 b c</td>
<td>± 9.13</td>
</tr>
<tr>
<td></td>
<td>(20.72)</td>
<td>(24.1)</td>
<td></td>
<td>(57.8)</td>
<td></td>
</tr>
<tr>
<td>STANDARD</td>
<td>618.24</td>
<td>277.69</td>
<td>0.18</td>
<td>5.44</td>
<td>0.11</td>
</tr>
<tr>
<td>3.66 m</td>
<td>± 130.54 f b</td>
<td>± 57.72 a</td>
<td>± 3.42</td>
<td>± 3.35 b</td>
<td>± 8.53</td>
</tr>
<tr>
<td></td>
<td>(21.1)</td>
<td>(20.8)</td>
<td></td>
<td>(61.6)</td>
<td></td>
</tr>
<tr>
<td>BELLY</td>
<td>643.33</td>
<td>286.32</td>
<td>0.06</td>
<td>5.69</td>
<td>-0.44</td>
</tr>
<tr>
<td>3.66 m</td>
<td>± 135.28 f</td>
<td>± 57.59 a</td>
<td>± 2.93</td>
<td>± 2.94 c</td>
<td>± 9.13 c</td>
</tr>
<tr>
<td></td>
<td>(21.0)</td>
<td>(20.1)</td>
<td></td>
<td>(51.7)</td>
<td></td>
</tr>
<tr>
<td>LONG</td>
<td>658.15</td>
<td>290.64</td>
<td>0.06</td>
<td>4.92</td>
<td>1.14</td>
</tr>
<tr>
<td>3.66 m</td>
<td>± 122.07 b</td>
<td>± 53.81 a</td>
<td>± 2.92</td>
<td>± 2.71 b c</td>
<td>± 8.17 c</td>
</tr>
<tr>
<td></td>
<td>(18.6)</td>
<td>(18.6)</td>
<td></td>
<td>(55.1)</td>
<td></td>
</tr>
</tbody>
</table>

* a between clubs p < 0.05, post-Hoc 1v2, 1v3  
  b between clubs p < 0.05, post-Hoc 1v3  
  c between clubs p < 0.05, post-Hoc 2v3  
  d between clubs p < 0.05, post-Hoc 1v3, 2v3  
  e between clubs p < 0.05, post-Hoc 1v2, 2v3  
  f between clubs p < 0.05, post-Hoc 1v2

BSTIME = backswing time, TIMP = forward swing time from beginning of the forward swing to impact with the ball, FACEIMP = putter face angle at impact, ROTIMP = putter face rotation angle from the beginning of the forward swing to impact, SPOTIMP = horizontal putter impact spot from geometrical centre.

CV not appropriate for negatively expressed angular data FACIMP and SPOTIMP.