

Investigating factors that improve golf scores by comparing statistics of amateur golfers in repeat scramble strokes and one-ball conditions

TAKERU SUZUKI¹, JOHN PATRICK SHEAHAN², ISAO OKUDA³, DAISUKE ICHIKAWA⁴ 

¹Professional Golfers Association of Japan, Tokyo, Japan

²Faculty of Sport Science, Yamanashi Gakuin University, Yamanashi, Japan

³Department of Human Development and Sport Sciences, Tokyo International University, Saitama, Japan

⁴Department of Biomedical Engineering, Toyo University, Saitama, Japan


ABSTRACT

This study investigated how scores and statistics of amateur golfers changed when self-scramble (SC) was compared to normal play. Participants took two (SC2) to three (SC3) golf strokes each. Scores under these conditions were compared with those from normal round (NR) play to determine to what extent the scores and statistics would improve. Means, standard deviations, repeated measures one-way ANOVA, and a forward stepwise multiple regression analysis were performed for data analysis. The mean total score over nine holes by NR plays was 46.6 strokes, with a significant reduction of 7.7 strokes and 10.6 strokes under SC2 and SC3 conditions, respectively. Even when the three play conditions' total scores decreased significantly for all subjects, the putt rate was around 38%, suggesting that the ratio of the number of putts per score did not change when play conditions changed. Stepwise multiple regression analysis for NR and SC2 using total score as the dependent variable and each statistic as the independent variables showed that greens in regulation (GIR) predicted 51.2% of the total score for NR; GIR and the One-Putt rate predicted 87.3% of the total score for SC2. These findings indicate that GIR is the most important factor for reducing non-professional golfers' total scores. This study suggests that players gain experience in reducing their golf scores in a format that is similar to an actual game of golf.

Keywords: Performance analysis; Non-professional golfers; Greens in regulation; Putt rate.

Cite this article as:

Suzuki, T., Sheahan, J.P., Okuda, I., & Ichikawa, D. (2020). Investigating factors that improve golf scores by comparing statistics of amateur golfers in repeat scramble strokes and one-ball conditions. *Journal of Human Sport and Exercise*, in press. doi:<https://doi.org/10.14198/jhse.2021.164.09>

 **Corresponding author.** Toyo University Sports and Health Science Laboratory. 2100 Kujirai, Kawagoe, Saitama, 350-8585, Japan. <https://orcid.org/0000-0003-2987-1689>

E-mail: ichikawa@toyo.jp

Submitted for publication April 15, 2020

Accepted for publication May 22, 2020

Published in press June 04, 2020

JOURNAL OF HUMAN SPORT & EXERCISE ISSN 1988-5202

© Faculty of Education. University of Alicante

doi:10.14198/jhse.2021.164.09

INTRODUCTION

Modern-day golf has a predetermined number of strokes (par) ranging from par 3 to par 5. Par is determined based on the distance of each hole from tee placement to pin. Golf courses have nine holes in the first half and nine holes in the second half of the course. Each half has two par-3 holes and seven par-4 and par-5 holes, allowing for 36 strokes in each half. When the match play system is the primary form of competition, par is unnecessary; the player who uses fewer strokes than their opponent does wins the hole, and the player who wins the most holes wins the round. It is not clear when par became a consistent part of golf, but it spread rapidly after the invention of stroke play. In this method, which originated in 1759 at St. Andrews Links in Scotland, players compete to have the lowest number of total strokes on each round (Browning, 2018).

Golfers may choose from 13 different clubs, excluding putters, for each hole, with the goal of using fewer strokes than par. The rules of golf also dictate that it is not possible to re-hit or repeat strikes of the ball from the same position; thus, golfers must string together single strokes, and one mistake can significantly affect their score (R&A, 2019). Therefore, golf is considered one of the most difficult sports, requiring excellent mental and technical skills for each shot taken. Golf performance refers to the player's score; factors such as course management, strategy, and accuracy of swing and putting movements affect that score. In addition, because the slopes and lies (position of the golf ball) differ between each shot, golfers are required to maintain reproducibility of accurate ball contact.

Starting New at Golf (SNAG) is one of the popular methods for teaching children the basics of the game and eventually to play more seriously. SNAG includes scalable sport equipment developed by two professional American golfers in 2001 (Sams, 2015), and the method was developed to reduce the technical burdens required to play golf in earnest. For example, a child just beginning golfing may practice with a club that is lighter and has a shorter shaft, which reduces the difficulty of the golf swing. This reduces the physical, technical, and mental burden on the player and encourages successful experiences and a sense of exercise, similar to reducing ball size and lowering hoop height when learning basketball, or using a softball and lighter bat prior to learning baseball. In ground and putter golf, games use a smaller golf field, easier tools, and simplify the rules of golf, allowing for a more enjoyable experience. Golf rounds are simplified, and shorter versions of formal golf courses are effective for teaching novice golfers. However, the ultimate objective for amateur golfers is to navigate full-size golf courses while using a variety of golf clubs, according to the official rules of golf.

Professional golf instructors have searched for a methodology that focuses on developing a player's success experience, sense of movement, and game strategies in various playing conditions, all of which would lead to improved golf scores. The main difference between professional and amateur golf players is the success rate of strokes and course management in situations where the rules only allow a single stroke from each location. Instruction for amateur golfers lacks opportunities to experience rounds of play that allow multiple strokes from a single location on the course (as opposed to driving practice), as this would provide important feedback to the players. Broadie and Ko (2009) created a 6,500-yard computer-simulated course and derived the mean score for the game using a simulation method based on probability data of shots that used the best and worst shots. When the best ball format was adopted for all shots, the mean score of 80 for an amateur player reduced to 70, while a mean score of 90 became 78; this is compared to a score of 60 strokes from players in the PGA Tour Pro (Broadie, 2014). Nevertheless, there is a lack of fundamental data on how scores and statistics (fairway keep rate, par on rate, putting rate, etc.) vary when amateur golfers play just a single stroke versus when they are subjected to course management and strict rules but have the ability to perform

multiple hits (Broadie and Ko, 2009; Chae et al., 2018; Dorsel and Rotunda, 2001; Fried et al., 2004; Pfitzner and Rishel, 2005).

Therefore, this study aimed to investigate how the scores and statistics of amateur golfers would change with modifications to the original game rules (self-scramble, hereinafter SC), whereby participants are given multiple golf strokes from the same position and aim for holing-out by selecting the best ball after each stroke. This approach will assist players in applying the formal rules of golf, where only a single stroke from each position is allowed.

MATERIAL AND METHODS

Participants

The participants in this study were 10 average male golfers. All were right-handed players with an average age of 54.8 ± 12.5 (years), height of 171.5 ± 3.9 (cm), and weight of 70.3 ± 6.7 (kg). The number of years of experience playing golf was 18.3 ± 13.1 (years), with the best lifetime score being 83.3 ± 6.9 (strokes). The average score of three rounds played on the same nine holes was 46.5 ± 4.8 (strokes). The average club head speed of 1 wood was 40.0 ± 1.8 (m/s). Club head speed was measured over five shots using the TrackMan system (TrackMan A/S, DEN) before the measurement of course statistics.

Measures

The participants played golf in the presence of PGA expert instructors, who made a record of their performance after completing each hole. This was done using a scorecard provided in advance; both the total score and other statistical data could be recorded.

Total score (strokes)

The total score through nine holes. To analyse the results of nine holes and the participants' abilities reflecting the individual typical play style, the median of three scores was analysed for a normal round (NR) and self-scramble 2 round (SC2). As a self-scramble 3 round (SC3) causes sufficient physical and time burden on participants, only a single score was used for analysis. Preliminary experiments for SC3 showed that the standard deviation for multiple scores was very small (less than ± 2).

Golfing statistics in the 9-hole round system

Driving accuracy (Fairway keep) rate (%): The probability of the ball landing on the fairway from a tee-shot (seven holes excluding the par 3 hole). In SC2 and SC3, the shot was deemed successful if the selected ball had landed on the fairway.

Greens in regulation (GIR) rate (%): The probability describing the number of situations during nine holes where a par could have been achieved with two putts. This means the ball was on the green during the first drive for par-3 holes, the second shot for par-4 and the third shot for par-5; it was also referred to as "par on." In SC2 and SC3, the shot was deemed successful if the ball selected was "par on."

Scrambling rate (%): The probability of a par or lower score when there was no par on.

One-putt rate (%): The probability of ending with a single putt through each of the nine holes.

Putts per round (strokes): The total number of putts across the nine holes after a drive landing on the green.

Putt rate (%): The proportion of the total putt count relative to the score.

Frequency of double-bogey or more (times): The frequency of a double-bogey (two strokes over par) or worse score through the nine holes.

Procedure

Information sheets containing a summary of the study approved by the T University Academic Research Ethics Review (2018-15) were distributed to the participants. Before participating, individuals were required to provide written consent. The study was conducted in accordance with the protection of human rights in the Declaration of Helsinki, in order to prioritize respect and security for individuals in all processes. The participants were informed that they had the freedom to withdraw from the study at any time.

The experiments were carried out at the same 9-hole golf course (Front 9 course in PGA Taiheiyō Club Mashiko, Tochigi Prefecture, JP) during 2017–2018. Elements that contributed to course difficulty were excluded as much as possible. The total distance for the course was between 3,192 and 3,343 yards and 36 strokes was considered par for the front 9 (Figure 1). We explained the rules and round system of the day to the participants and ensured that they understood them prior to starting rounds. The participants used the following three types of round systems. In an NR, players play one stroke according to the normal rule; in an SC2 round, players are allowed two balls for each stroke; and in a SC3 round, players are allowed to play three balls for each stroke, and may choose the best ball until hole-out to lower their score.

HOLE NO.	HDCP	Champion	Back	Regular	Front	Ladies	PAR
1	9	591	554	533	514	465	5
2	3	450	433	411	386	336	4
3	15	341	341	323	297	282	4
4	7	213	190	170	170	153	3
5	1	536	511	496	496	454	5
6	13	191	180	160	139	121	3
7	11	378	356	356	330	314	4
8	5	415	392	378	378	315	4
9	17	413	386	365	346	293	4
OUT		3,528	3,343	3,192	3,056	2,733	36

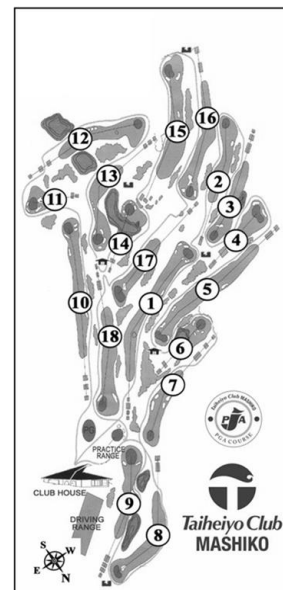


Figure 1. Golf course layout and hole by hole distances in this study.

Round setting based on the self-scramble rule

The participants were requested to hole-out with the smallest number of strokes during all three round formats. For all strokes, the Preferred Lies rule was applied to allow the ball to be placed within one club-length without approaching the hole. This is because when hitting the second and third balls, it is difficult to reproduce the exact same position and state of the ball, and undetermined elements such as the ball being

in a divot need to be eliminated as much as possible. A single party could include up to four people for NR, up to three people for SC2, and up to two people for SC3; this was to ensure no differences in play time or fatigue level over the nine holes, and to maintain safety during rounds. Participants were also instructed to switch with the next player in line after hitting the second or third ball consecutively. In SC2 and SC3, regardless of the quality of the shot and the remaining distance to the cup, the players selected the best ball that they judged to be advantageous to reduce their score. In SC2 and SC3, if players judged that they had taken their best stroke in the first or second stroke, they were allowed to move on to the next location. Participants were also allowed to receive feedback on the results of the first or second hit and change the club being used or change their aim. A participant was judged to have holed-out if the ball had finished inside the cup from outside of the green. In SC2 and SC3 on the putting green, a participant was judged to have holed-out if he made the cup with the first or second stroke, and any further putting strokes were prohibited. To consider the participants' concentration levels while participating in the experiments as well as the influence of fatigue, each participant was restricted to nine holes of play in one type of round format per day. Each participant also played through the three round formats in a random order.

Analysis

Total score and statistical items were reported using the mean value and standard deviation (SD) in the three different round systems (NR, SC2 and SC3). Repeated measures one-way analysis of variance (ANOVA) was used to assess the different round systems. Post-hoc tests used multiple repeated measures t-test with Bonferroni correction (NR vs. SC2, NR vs. SC3, and SC2 vs. SC3). All data were assessed for normality and sphericity using Mauchly's test. If the Mauchly's sphericity assumption was violated, Greenhouse-Geisser corrections were used. A partial eta-squared (η^2) was used to calculate the effect size (small = 0.01, medium = 0.06, and large = 0.14) (Toms, 2017). A forward stepwise regression analysis was performed to generate predictive models using the total score as the dependent variable. Predictor variables included seven statistical items. If the variance inflation factor was < 5, multicollinearity did not occur. All significance levels were set to .05, and statistical analysis was performed using SPSS version 24.0 software (SPSS, IBM, JP).

RESULTS

Table 1 shows the results of scores and other statistical data in NR, SC2, and SC3 groups. The total scores were 46.6 ± 3.3 in NR, 38.9 ± 2.6 in SC2, and 36.0 ± 2.5 in SC3. There was a significant difference between NR and SC2 and SC3. SC2 was approximately 7.7 strokes lower than NR. SC3 was lower than NR (approximately 10.6 strokes). Furthermore, the total SC3 score was lower than SC2 score (approximately 2.9 strokes). The fairway keep rate showed a significant increase from NR to SC3 round (approximately 38.6%). GIR rates significantly increased from NR to SC2 (approximately 21.1%) and from NR to SC3 (approximately 32.2%). The scrambling rate showed a significant increase from NR to SC2 (approximately 33.5%) and from NR to SC3 (approximately 52.6%). The one-putt rate showed a significant increase from NR to SC3 (approximately 23.3%). The putt per round showed a significant decrease from NR to SC3 (approximately 3.5 strokes). The putt rate (putt per round/total score*100) showed no difference when all-round systems were considered ($F(2,18) = 0.23$, $p = .79$). The frequency of double-bogey or more showed a significant decrease from NR to SC2 (approximately 2.5 times). There was a significant decrease from NR to SC3 (approximately 3.1 times).

Table 2 shows the results of the stepwise regression analysis selecting potential predictor variables that satisfied the conditions in the NR and SC2. GIR was the only selected variable for total score in the NR, and R^2 was 0.566 ($p < .05$). Total score = $49.327 + (-16.364 * GIR/100)$. In addition, the GIR and one-putt rate were selected as explainable variables for total score in the SC2, R^2 was .901 ($p < .001$). Multiple regression

analysis generated the following equation for the total score = $47.936 + (-12.257 \cdot \text{GIR}/100) + (-11.330 \cdot \text{One-Putt}/100)$.

Table 1. Scores and statistics at NR, SC2 and SC3 in the golf round system.

	Total Score (Strokes)	(1) Fairway keep (%)	(2) GIR (%)	(3) Scrambling (%)	(4) One-putt (%)	(5) Putt per round (Strokes)	(6) Putt rate (%)	(7) D-Bogey or more (no. of times)
NR	46.6±3.3	37.1±21.5	16.7±15.0	16.7±15.7	21.1±12.2	17.2±1.4	37.1±4.1	3.3±1.4
SC2	38.9±2.6	51.4±19.3	37.8±24.1	50.2±18.7	38.9±15.9	14.8±1.9	38.1±5.1	0.8±0.4
SC3	36.0±2.5	75.7±24.3	48.9±24.7	69.3±25.2	44.4±9.1	13.7±1.3	38.1±3.1	0.2±0.6
ANOVA:								
F stat	78.9	7.5	12.2	20.5	9.1	11.7	0.2	30.5
p value	< .01	< .01	< .01	< .01	< .01	< .01	.79	< .01
η ²	.94	.53	.76	.89	.83	.75	.04	.78
Mean differences:								
NR vs SC2	7.7**	-14.3	-21.1*	-33.5**	-17.8	2.4	-1.0	2.5**
NR vs SC3	10.6**	-38.6*	-32.2**	-52.6**	-23.3**	3.5**	-1.0	3.1**
SC2 vs SC3	2.9**	-24.3	-11.1	-19.1	-5.6	1.1	0.0	0.6

Note: Values are Mean ± SD, n = 10, normal round (NR), self-scramble (SC), greens in regulation (GIR), * (p < .05), ** (p < .01).

Table 2. Relationship between total score and each statistic in SC2 using stepwise analysis.

	B	SE B	β	t	p	R ² (Adjusted R ²)	VIF
Step 1						.566 (.512)	
GIR (%)	-7.981	2.470	-7.520	-3.231	.012		1.000
Step 2						.901 (.873)	
GIR (%)	-12.257	1.534	-1.155	-7.991	.000		1.484
One-putt (%)	-11.330	2.322	-0.706	-4.880	.002		1.484

Note. N = 10, self-scramble 2 (SC2), greens in regulation (GIR) rate, one-putt (One-putt) rate partial regression coefficient (B), standard error (SE B), standardized partial regression coefficient (β), t value (t), significance probability (p), determination coefficient (R²), adjusted determination coefficient, R² (Adjusted R²), variance inflation factor (VIF).

DISCUSSION

We hypothesized that the total score over the 9-hole course would be reduced for SC2 and SC3 conditions compared to NR because of the higher number of stroke opportunities. As a result, we were able to determine whether an amateur golfer would be able to complete the round with a score that is approximately 3 over par when each stroke can be taken twice or with a score of par if each stroke could be taken three times. Stepwise multiple regression analysis performed using the total score as the dependent variable and each statistic as an independent variable showed that GIR predicted 51.2% of the total score for NR, and GIR and one-putt rate predicted 87.3% of the total score for SC2. These findings suggest that GIR is the most important factor for reducing the total score for an average golfer.

Recently, there has been rapid evolution of play analysis in the world of golf. In particular, the USPGA Tour has constructed a data collection system called "Shot Link" (Stöckl et al., 2013; Stöckl and Lamb, 2018). This system introduces laser technology to collect data on 10 million or more shots at an error of < 5 cm on green surfaces and < 90 cm on non-green surfaces in order to analyse golf play (Broadie, 2012, 2014). Based on such a vast amount of data, Broadie (2014) used a simulated model to set a course of 6,500 yards and show the predicted SC2 score at three levels ability for both professional and amateur golfers. The simulated

prediction over 18 holes for a player having a mean score of 90 strokes in NR was 78 strokes in SC2. Over 9 holes, to fit this experiment, a 39 stroke score was used. This is similar to the results obtained in this study. This study demonstrated that achieving an optimal average flight distance and range of swing technique by an average golfer would make it possible to reduce the score down to a level that is close to par. Improving shot accuracy and avoiding gross errors during the stroke combined with making correct course management decisions and appropriate adjustments while putting to reach the green area properly as well as hitting the ball with proper distance and direction, can result in achieving par scores while golfing.

Fairway keep rate

Comparing the results of the three round formats, the fairway keep rate significantly improved relative to NR when the strokes were repeated three times. Although we had predicted that the fairway keep rate would contribute to reducing the golf score, analysis of actual data showed that this was not the case. We were able to deduce that, for an average golfer, the score was not greatly affected by whether the ball landed in the fairway or in the rough after the initial drive; what was important was whether the position of the ball allowed players to aim for the green with their subsequent shot.

From a professional golf coach's standpoint, under normal playing conditions, where the length of the grass in the rough area is not long, it is not necessary to stick to keeping the ball on the fairway by hitting the best shot to the centre of the fairway; instead, it is more important to avoid a penalty area such as a pond or out of bound (OB) region, and dangerous sides such as the valleys and deep bushes, which are very likely to produce a double-bogey or worse. In other words, the first approach should be to aim for a direction that would allow players to avoid these difficult areas, even if these shots would place the ball in the rough.

GIR

Although SC2 and SC3 showed significant differences compared to NR in terms of GIR, there were no significant differences in GIR between SC2 and SC3. We speculated that GIR would not rise higher with more than three chances given to hit the ball. Furthermore, factors such as the remaining distance to the green also affected the GIR. If we were to consider the average skill of an amateur golfer, it is speculated that the GIR rate would improve with the shot repeated twice if the distance to the green was 100 yards. However, if the distance were approximately 200 yards, it is very likely that the golfer would fail to par even if the shot could be repeated more than three times. Because GIR was the most important factor for the score according to the results of the multiple regression analysis in this study, amateur golfers should focus more on strategies to increase the likelihood of par during rounds. The USPGA Shot Link collected official statistics of approximately 200 tour members including the GIR according to distance (PGA TOUR Champions, 2018a). Considering the results of the 100th place, which is approximately the median result of all tour members in 2018, the GIR was high at 81.74% for a distance less than 125 yards; by contrast, the GIR reduced to 46.23% over a distance of 200 yards or more. This indicates that even for professional golfers, the GIR is greatly affected by the remaining distance.

Under SC2 and SC3 conditions of this study, we adopted a rule that allowed participants to change their clubs based on feedback received from the first shot. As such, we believe that the GIR improved for short distances and low difficulty shots because participants could make corrections to distance judgment and club selection in addition to correcting a missed hit. Although the lack of shot ability is thought to be a major factor in determining GIR; during the actual experiment, poor course management and situation judgment caused many nice shots to fail to land on the green. An average golfer may be able to raise their GIR even further if they can improve their ability to accurately select clubs based on their judgment of distance, which considers inclinations, such as uphill and downhill and differences in height to the green, in addition to the influence of

headwinds and tailwinds. However, for long-distance shots of around 200 yards, because ball control itself becomes more difficult, simply correcting the situational judgment would not lead to improvement in GIR. Instead, the swing and ball control must also be improved. These findings suggest that improving shot accuracy through basic long-distance shot practice on a driving range and extending the driver flight distance to reduce the distance remaining to the green will be beneficial.

Scrambling rate

The scrambling rate, which shows the probability of achieving a score of par or better when a golfer misses par on, was approximately 50% under SC2 conditions, suggesting that golfers succeeded in scrambling half of the time that they had missed par on. This value was similar to the scrambling of the lowest ranked player according to the 2018 USPGA Official Statistics, and a scrambling success rate of 69% under SC3 conditions was similar to that of the highest ranked USPGA player (PGA TOUR Champions, 2018b). Playing under SC2 conditions or more increased the opportunities to select the best ball, thereby making it possible to avoid various problem areas. For this reason, even if the player did not successfully achieve par on, they were able to achieve a high scrambling success rate by taking an approach shot from a distance and choosing a site of relatively low difficulty.

According to a recent report, “quantifying the penalty for missing the short side” is a factor when the approach shot is taken from the shorter side or from the longer side relative to the pin flag (Broadie, 2019). Using this approach, the authors showed that there would be a difference in the number of strokes needed to cup-in when the approach shot was taken from the short side at approximately 20 yards away, and also when the approach shot was taken from the long side from the same distance. The authors reported that 2.8 strokes were needed from the short side while 2.4 strokes were needed from the long side, which is a 0.4 stroke reduction in the long side. Therefore, even if the direct distance to the pin was the same, aiming for the pin from the long side would reduce the number of strokes.

In the present study, because players themselves were able to select the ball that give them the best chance of reducing their scores regardless of the remaining distance, there was very little need for them to challenge an approach shot, which is very difficult. For example, they were able to select a ball that was 30 yards out in the long side on a flat surface in the rough rather than a ball that was only 15 yards out in the short side but situated in a deep bunker. This may have been a factor that increased the scrambling rate in SC2 and SC3 conditions. Because professional golfers tend to aim to stop the ball on the long side even during normal play when they could achieve par, an average player would need to successfully choose the shot direction after surveying the course. Furthermore, the difficulty of a shot is affected when the ball stops in a bunker or on a slope; according to the lie condition, it would be important for golfers to practice the difficult shot in order to raise their scrambling rate in such situations.

One-putt rate

Only SC3 showed significant improvement in the one-putt (%), which is an indicator of putting ability, relative to NR. One-Putt Percentage is recorded as part of the official statistics of the PGA Tour (PGA TOUR Champions, 2018c). The top 20 players of the One-Putt Percentage Rankings in the 2018 PGA Tour recorded 44% or higher, which was around the same as the results under SC3 conditions in the present study.

A study that examined coordination patterns based on the movement of the crown of the head and putter head during putting reported that the phenomenon seen in novice golfers, where the horizontal movement of the crown toward the target direction before and after impact was synchronized, is unlikely to improve with a small practice stroke count of 50 balls (Ishikura, 2010; Lee et al., 2008). Another study reported that, for a

high-skill golfer, the importance of reading the green while putting (green reading) reached 60% and proved to be more important than stroke technique (34%) (Karlsen and Nilsson, 2008). If we consider this, it is difficult to suppose that the stroke pattern itself improved between the second to third strokes for an average golfer; rather, we believe that the results improved because adjustments were made to the distance to the target and the stroke direction. These adjustments were made based on repeating the situational judgment with increased information from the putting green. It is unlikely that the participants gained the same accuracy of stroke motion as professional golfers between the second to third repeated stroke (Suzuki et al., 2019).

Many putting instructions primarily involve stroke form practice. However, what is needed for putting on a course is the skill of being able to read the distance and direction suited to the situation and to make a stroke accordingly. It is true that the more advanced a player's skills become, the greater the need to make minor stroke pattern adjustments; however, green reading should be given more importance at any skill level.

Putts per round

As with the one-putt rate, the putts per round did not show any significant improvements except in SC3. Thus, the one-putt rate increased and putts per round decreased as three chances were given for a stroke. The putts per round in this study were equivalent to half the value of 27.82 strokes per round for the top players in the 2018 PGA tour rank converted to nine holes (PGA TOUR Champions, 2018d). In addition to putting skill, aspects affecting concentration also affect putting performance (McDaniel et al., 1989; Smith et al., 2003; Tanaka and Sekiya, 2010; Tanaka and Sekiya, 2011).

A study of putting reported that, in golfers participating in an amateur competition with strong tendencies toward anxiety based on the State-Trait Anxiety Inventory test, players were unable to perform a normal stroke for a short putt of less than 2 m in distance. Moreover, an undershooting phenomenon occurred, whereby the back swing became shorter and the impact speed decreased compared to normal conditions (Hasegawa et al., 2013). Under NR conditions that only allow a single hit, anxiety continues into subsequent stroke when a player fails to make the cup-in. It becomes difficult to perform challenging putting, such as when the ball glides over the cup, and in many cases, the player would be forced to perform a putt under anxiety. By contrast, under SC3, players were able to perform the first putt with mental leeway, as they knew they would be allowed to take total of three strokes. Furthermore, if a player managed to stop the ball at a position that was 30-cm away from the cup with the first stroke, and in so doing was certainly able to tap it in with the next putt, he would be able to perform a challenging stroke for the second and third repeat strokes without any anxiety. We believe that, under SC3 conditions, in addition to the advantage of green reading and adjustment of distance and direction, the reduced psychological pressure may have also contributed to a significant decrease in the number of putts per round.

Putt rate

A previous study reported that the putt rate, which is a ratio of the score to the putt count, is approximately 43% (Pelz and Mastroni, 2004). In the present study, this value was approximately 38% across all three play conditions, suggesting no significant differences in putt rate across any play condition. Although the total score decreased significantly as the play format changed, it did not make any significant changes to the ratio of strokes and putts in a golf game. One of the purposes of this study was to allow average amateur golfers to gain experience in reducing their golf scores in a format that was similar to an actual game of golf. The participants succeeded in having a simulated experience of score-making with statistics that could be compared to those of professional or expert golfers. Furthermore, the players were also able to build up round experience in order to achieve improvements in the future.

Double-bogey or more

Although the number of double-bogey was approximately 3.3 times under NR conditions, there was a significant decrease in this value to approximately 0.8 times under SC2 conditions. Because the present study allowed the selection of balls in a favourable position for the next stroke, participants were able to reduce the number of double bogeys by avoiding various trouble areas. The skill level of an average golfer is too low to avoid elements such as OB and penalty areas under NR conditions, and they are generally too inexperienced to make appropriate immediate situational judgments. This is why their scores are expected to become worse. Therefore, golfers should undergo round training that adopts the best ball format because this will allow them to experience the achievement of par by advancing the play while avoiding difficult elements, even if they are not able to make a perfectly executed shot. Furthermore, the fact that there was such an extreme reduction in the number of double-bogeys or more in the self-scramble format suggests the possibility that golfers may learn ways to avoid sporadic occurrences of higher scores. We can then understand that it is important for a player to review and gain feedback about the round format data and to minimize the variation (SD) in scores for each hole to reduce the total score.

This study showed that the number of double-bogeys or more could be reduced under SC2 conditions. From this we may deduce that, between the two strokes taken, improving the quality of the worse shot would lead to preventing larger scores, while the better shot would be of a high enough quality to successfully complete nine holes in 39 strokes. As such, the occurrence of a large score can be reduced by carefully choosing a stroke strategy that fits the situation and avoiding terrible miss-shots during the rounds.

Typically, to demonstrate whether a training method that uses best ball format is effective for reducing the total score, it is necessary to compare the NR score before and after a certain training period. However, this was difficult in this study because of the time constraints imposed by each participant having to play through a 9-hole round seven times or more while taking records. Conversely, the best ball format played over 9 holes allowed even amateur golfers to maintain their concentration by eliminating the accidental and unlucky parts of golf as much as possible.

Since players recorded their play stats during the round, no measurement of GIR or putt counts were taken relative to the remaining distance. As such, we were unable to clarify the relationship with these statistics versus distance. To date, the evaluation of putting performance has primarily relied on the one-putt rate and putts per round as indicators. However, these indices do not consider the remaining putting distance, and putting skill to the distance cannot be accurately determined. The recently introduced Shot Link system makes it possible to measure the positions where the ball has moved on the green. The “strokes gained putting” indicator uses this data to show the putt success rate relative to the remaining distance; and this is now used as an indicator of putting skill (Broadie, 2014). Because only the conventional method could be used in this study given that the golf course had no laser system and the players themselves had to record the statistics, we hope to examine these variables in the future.

This approach would make it possible to accurately evaluate players' technical abilities in a way that avoids high scores on holes. In addition, this approach may be used as a measure to replace a handicap when rounds are being played by individuals of different technical levels in golf. Furthermore, considering player fatigue, time needed, and the safety of playing with multiple golfers, we considered that the more realistic playing format is the SC2 condition over nine holes with three players per group. Finally, if golf is to be played by repeating shots 2-3 times, this should be done with the permission of the golf course.

CONCLUSIONS

Compared to NR, total scores under the SC2 and SC3 conditions reduced by 7.7 strokes and 10.6 strokes, respectively. Despite the change in round conditions and the reduction in total strokes, there were no significant changes to the putt rate, and the significant improvement in GIR rate was shown to contribute most to the reduction of score.

When SC2 and SC3 results were compared, there were no significant differences between any of the statistics, other than the score. Therefore, for an average golfer, it is important to repeat the 9-hole round training under SC2 conditions and receive feedback for self-analysis, taking safety and practicality into consideration, in order to achieve par play.

AUTHOR CONTRIBUTIONS

Takeru Suzuki (The conception or design of the work, analysis). John Patrick Sheahan (Drafting the work or revising). Isao Okuda (Interpretation of data for the work). Daisuke Ichikawa (Drafting the work or revising, agreement to be accountable for all aspects of the work).

SUPPORTING AGENCIES

No funding agencies were reported by the authors.

DISCLOSURE STATEMENT

The author(s) declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

ACKNOWLEDGMENTS

We would like to extend our deepest gratitude to the Pacific Club Mashiko PGA Course (JP) that provided us with the experiment venue and helped us greatly, the players of the PGA Academy Mashiko that participated in the experiments, and the joint researchers that collaborated with us for this study. We would like to thank Editage (www.editage.com) for English language editing.

REFERENCES

- Broadie, M. (2012). Assessing golfer performance on the PGA TOUR. *Interfaces*, 42(2), 146–165. <https://doi.org/10.1287/inte.1120.0626>
- Broadie, M. (2014). *Every shot counts: Using the revolutionary strokes gained approach to improve your golf performance and strategy*. New York, NY: Penguin Group.
- Broadie, M. (2019). Quantifying the penalty for missing on the short side. <https://www.golf.com/instruction/2019/02/26/mark-broadie-new-pga-tour-stats-statistic-short-sided-index>
- Broadie, M., & Ko, S. (2009, December). A simulation model to analyze the impact of distance and direction on golf scores. Paper presented at the Proceedings of the 2009 Winter Simulation Conference (WSC), Austin, TX. <https://doi.org/10.1109/wsc.2009.5429280>

- Browning, R. (2018). *A history of golf: The royal and ancient game*. Whitefish, MT: Literary Licensing, LLC.
- Chae, J. S., Park, J., & So, W. Y. (2018). Ranking prediction model using the competition record of ladies professional golf association players. *Journal of Strength and Conditioning Research*, 32(8), 2363–2374. <https://doi.org/10.1519/JSC.0000000000002018>
- Dorsel, T. N., & Rotunda, R. J. (2001). Low scores, top 10 finishes, and big money: An analysis of professional golf association tour statistics and how these relate to overall performance. *Perceptual and Motor Skills*, 92(2), 575–585. <https://doi.org/10.2466/pms.2001.92.2.575>
- Fried, H. O., Lambrinos, J., & Tyner, J. (2004). Evaluating the performance of professional golfers on the PGA, LPGA and SPGA tours. *European Journal of Operational Research*, 154(2), 548–561. [https://doi.org/10.1016/S0377-2217\(03\)00188-7](https://doi.org/10.1016/S0377-2217(03)00188-7)
- Hasegawa, Y., Koyama, S., & Inomata, K. (2013). Perceived distance during golf putting. *Human Movement Science*, 32(6), 1226–1238. <https://doi.org/10.1016/j.humov.2013.02.003>
- Ishikura, T. (2010). Learner-regulated feedback enhances ball putting learning. *Journal of Sport and Exercise Psychology*, 32, S89–S89.
- Karlsen, J., & Nilsson, J. (2008). Distance variability in golf putting among highly skilled players: The role of green reading. *International Journal of Sports Science & Coaching*, 3(1_suppl), 71–80. <https://doi.org/10.1260/174795408785024333>
- Lee, T., Ishikura, T., Kegel, S., Gonzalez, D., & Passmore, S. (2008, 07/01). Head-putter coordination patterns in expert and less skilled golfers. *Journal of Motor Behavior*, 40, 267–272. <https://doi.org/10.3200/JMBR.40.4.267-272>
- McDaniel, K. D., Cummings, J. L., & Shain, S. (1989). The “yips” A focal dystonia of golfers. *Neurology*, 39(2), 192–192. <https://doi.org/10.1212/wnl.39.2.192>
- Pelz, D., & Mastroni, N. (2004). *Putt like the pros: Dave Pelz's scientific way to improving your stroke, reading greens, and lowering your score*. London, UK: Aurum.
- Pfizner, C. B., & Rishel, D. T. (2005). Performance and compensation on the LPGA tour: a statistical analysis. *International Journal of Performance Analysis in Sport*, 5(3), 29–39. <https://doi.org/10.1080/24748668.2005.11868335>
- PGA TOUR Champions, PGA TOUR Inc. (2018a). Categories-Approach the green. https://www.pgatour.com/stats/categories.RAPP_INQ.html
- PGA TOUR Champions, PGA TOUR Inc. (2018b). Statistics » Around the green » Scrambling. <https://www.pgatour.com/stats/stat.130.html>
- PGA TOUR Champions, PGA TOUR Inc. (2018c). Statistics » Putting » One-Putt Percentage. <https://www.pgatour.com/stats/stat.413.html>
- PGA TOUR Champions, PGA TOUR Inc. (2018d). Statistics » Putting » Putts Per Round. <https://www.pgatour.com/stats/stat.119.y2018.html>
- R&A. (2019). *The Official Guidebook to the Rules of Golf*. Hamlyn.
- Sams, L. D. (2015). *Perceptual differences in children learning to play golf with traditional or modified (scaled) equipment* (Unpublished doctoral dissertation). University of Arkansas, Fayetteville.
- Smith, A. M., Adler, C. H., Crews, D., Wharen, R. E., Laskowski, E. R., Barnes, K., & Smith, J. (2003). The 'yips' in golf: a continuum between a focal dystonia and choking. *Sports Medicine*, 33(1), 13–31. <https://doi.org/10.2165/00007256-200333010-00002>
- Stöckl, M., Lamb, P., & Lames, M. (2013). The ISOPAR method: A new approach to performance analysis in golf. *Journal of Quantitative Analysis in Sports*, 7, 1–15. <https://doi.org/10.2202/1559-0410.1289>
- Stöckl, M., & Lamb, P. F. (2018). The variable and chaotic nature of professional golf performance. *Journal of Sports Sciences*, 36(9), 978–984. <https://doi.org/10.1080/02640414.2017.1347269>

- Suzuki, T., Manabe, Y., Arakawa, H., Sheahan, J. P., Okuda, I., & Ichikawa, D. (2019). A comparison of stroke distance error from dominant and non-dominant putting stance in professional and novice golfers. *International Journal of Golf Science*, 7(1), 1–15.
- Tanaka, Y., & Sekiya, H. (2010). The influence of audience and monetary reward on the putting kinematics of expert and novice golfers. *Research Quarterly for Exercise and Sport*, 81(4), 416–424. <https://doi.org/10.1080/02701367.2010.10599702>
- Tanaka, Y., & Sekiya, H. (2011). The influence of monetary reward and punishment on psychological, physiological, behavioral and performance aspects of a golf putting task. *Human Movement Science*, 30(6), 1115–1128. <https://doi.org/10.1016/j.humov.2011.04.008>
- Toms, M. (2017). *Routledge international handbook of golf science*. London, UK: Routledge.

