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ARTICLE

A Pilot Study Investigating the Impact of a Pressure Mat Intervention on the Performance of Novice Golfers

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Centre of pressure and weight transfer can have a positive impact on golf performance (Ball & Best, 2007, 2012). To develop proper weight distribution throughout the golf swing, pressure mats have been introduced to help golfers track their pressure during the swing. These devices track a player's weight distribution throughout the swing. Recommendations have been suggested to improve performance however, research investigating the effectiveness of pressure mats has yet to emerge. Therefore, the purpose of this study was to compare the use of a pressure mat intervention to control and certified instruction groups to determine its ability to improve performance. Thirty novice golfers (10 per group) participated in the study. Each group participated in four sessions which included a baseline session and three experimental sessions. Performance was assessed by the 'shot-value', which is represented as total distance minus lateral distance. Nonsignificant results were obtained between the groups. Results are discussed in light of practice methods used to enhance performance.

Keywords: pressure, weight distribution, golf performance

The set of motor skills required to hit a golf ball effectively is complex and can be affected by many physical, psychological, and social factors. For example, physical factors could include postural and balance components (Ball & Best, 2012; Hrysomallis, 2011). Psychological factors may include confidence and anxiety, while social factors may include stress provoked from hitting in front of others (Chamberlain & Hale, 2007). To gain proficiency and minimize negative performance outcomes, participants typically engage in different types of practice. Past research has investigated how different practice methods can positively affect performance (e.g., Porter, Landin, Hebert, & Baum, 2007), and recommendations have been made to optimize practice schedules (Guadagnoli & Bertram, 2014; Lee & Schmidt, 2014).

In a recent review of the practice literature and how it relates to golf performance, Lee and Schmidt (2014) outlined the PaR (Plan-act-Review) process for

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improving golf skills. Generally, the PaR process focuses on planning and reviewing performance while minimizing constant repetition of the golf swing. Minimizing repetition of the golf swing, while focusing on the process of execution, is in line with previous work showing that blocked practice is less effective at learning than engaging in random practice (Shea & Morgan, 1979). The forgetting hypothesis has been put forth an as explanation for this phenomenon. This hypothesis suggests that individuals who undertake random practice schedules need to relearn the task upon presentation, which in turn engages them cognitively and enhances retention (Schmidt & Wrisberg, 2008).

Given that it is unusual for golfers to use the same club multiple times in a row, the PaR process is in line with random practice schedules and the forgetting hypothesis since it simulates how the game is usually played (Lee & Schmidt, 2014).

Concurrent to engaging in practice, golf participants can either enlist the services of a certified professional or use one of the many instruments promoted to improve skills. For example, the Medicus golf club is touted as an instrument capable of keeping the golf swing on plane while the GripIt Rite Trainer works to develop proper grip of the club. Individually or combined, certified instructions and specific instruments aim at addressing certain aspects of the golf swing with hopes of enhancing performance.

Of the many components that make up the golf swing, weight transfer has received recent research attention. It has been shown that weight transfer through the swing is important in generating more club head speed (Ball & Best, 2007) which can result in more distance (Ball & Best, 2012). Although weight distribution, and ultimately the trajectory of ones' center of pressure throughout the swing are deemed important for performance, individual patterns of pressure exist between individuals (Ball & Best, 2012) making it difficult to fully understand how to optimize performance using this measure. Recently, an instrument aimed at measuring distribution of pressure throughout the golf swing has been developed. This "pressure mat" tracks players' weight distribution throughout the golf swing and provides immediate feedback to the golfer on how much pressure is being placed on the leading foot versus trailing foot, and the amount of pressure placed on the heels versus toes. This creates a two-by-two model where feedback can be given to the participant on the pressure distribution for the x- (leading/trailing foot) and y- (heel versus toe) axes. It has been hypothesized that if players are able to consistently replicate a set of proper weight distribution parameters throughout the golf swing, then their ability to hit the ball more consistently (i.e., farther and straighter) will ensue. Although these recommendations have been put forth, there has yet to be any research investigating the validity of these claims and whether the pressure mat is effective in increasing a player's performance.

Therefore, based on this information, the purpose of this pilot study was to investigate the effectiveness of a golf pressure mat as an effective method of teaching golf to novice players[1]. In this study, the impact of the pressure mat as an effective instruction method was compared with two other conditions: a control condition and a certified golf instruction condition. It was hypothesized that both the pressure mat and certified instruction group would improve significantly more than the control group. Concurrent to the primary purpose, a secondary purpose was to examine the pressure traces in each group to explore if participants modified their trace throughout the study.

Method

Participants

A total of 30 participants enrolled in the study. Ten participants were female and twenty were male. The average age across all participants was 36.8 years of age (range: 19–68 years; *SD* = 14.7). All participants played less than 2 rounds of golf per week with 24 of the participants reporting that they played less than once per week. Ten of the 30 participants reported never playing golf before. Only five of the participants reported a golf handicap. Of the five reported handicaps, two players reported a value of 20, while two reported 11, and the last player noted a value of 7. No other playing ability information was collected from participants.

Upon registering for the study, participants were randomly assigned to one of the following three conditions: a control group, an instruction group with a certified golf professional, an instruction group using the pressure mat. This process resulted in ten individuals being randomized to each condition. In the control group, there were 4 females and 6 males with an average age of 29.9 years (*SD* = 14.2). The certified instruction group had 3 females and 7 males with an average age of 45 years (*SD* = 15). Finally, the pressure mat instruction group had 3 females and 7 males with an average age of 35.4 years (*SD* = 11.7). The control group was significantly younger than the certified instruction group (29.9 ± 14.2 versus 45 ± 15).

Procedure

Once participants were randomized to a condition, they were required to attend data collection sessions on four consecutive weeks. All of the data collection sessions were done at a local golf simulator and used the same simulator driving range. The simulator used in the current study was an HD Golf Model 16 simulator. Each participant was placed in a driving range setting (the same range was used with all participants) and were asked to hit balls toward the middle of the range. However, participants were not given a target distance at which to aim. The simulator provided a controlled environment in which participants could hit golf shots into a screen and allow for the collection of relevant data. The data collected during the study were total distance hit, total distance carried in the air (yards carried), and lateral distance from center. All data were collected in yards. To assess pressure distribution, pressure traces were recorded using the BodiTrak pressure mat (see Figure 1 for sample trace data). Each participant provided four pressure traces during every visit, which was the first shot taken with each club. A pressure trace was only recorded for the first shot for two reasons: first, it was believed that the swing would be constant over the series of shot, and second it was done to save time during the data collection process as recording traces is a time-consuming process.

On week one, which was used to collect baseline information, data collection began with participants reading the letter of information and signing a consent form. Following this, demographic information was collected. This included their name, sex, number of years playing, number of rounds played per week, and golf handicap (if known). Participants were then provided with an opportunity to warm up until they were ready to proceed with the baseline test. The test asked all participants to hit 40 golf shots. Ten shots were hit with each of the following four clubs: 9 iron, 5 iron, 3 wood, and driver. The same clubs and order of clubs (9 iron, 5 iron, 3

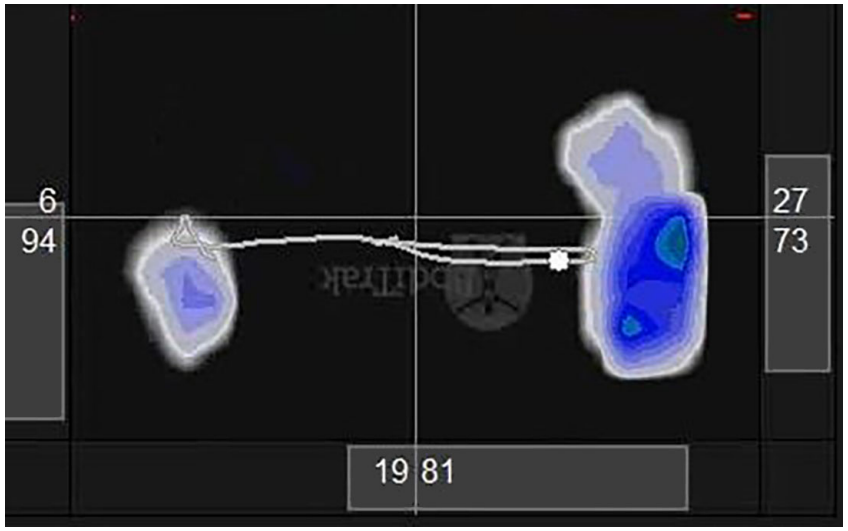


Figure 1 Example of pressure trace data collected from the mat. The x-axis represents leading foot/trailing foot pressure and the y-axis showing heal-to-toe pressure patterns.

wood, driver) was used for all participants and data collection sessions. For each shot hit, total yards, yards carried, and dispersion were recorded. For the first shot hit using every club, the pressure trace was taken. The data collection process for week 1 took approximately 30 minutes per participant.

During the second, third, and fourth weeks of data collection, participants engaged in different activities based on the condition into which they were assigned. Participants in the control group were provided access to the simulator and given no more than 30 minutes to practice. No instruction or feedback was provided. Following this, participants completed the data collection phase which included hitting the 40 shots described above, with the pressure trace also being taken on the first shot of every club. Between simulator visits, player practice/play was not monitored. However, given that most participants did not play golf regularly, it is believed that additional practice/play occurred infrequently and did not impact the study.

On the weeks following baseline, participants in the certified instruction group received a 30-minute lesson with a golf instructor. The same instructor was used throughout the duration of the study. The instructor worked with each participant using his usual techniques. Since participants were novice players, the lessons revolved around basic instruction and touched on topics related to proper grip, stance, and swing plane. Participants worked with all the clubs included in the study to gain familiarity with different club types. Following the 30-minute lesson, participants were asked to hit the 40 shots described above and provide the required pressure traces.

A similar process was used with participants in the pressure mat group; however, rather than receiving lessons from a certified instructor they were taught how to

properly distribute their weight throughout the golf swing. Participants were taught the weight distribution at three key positions during the golf swing: address, transition, and impact. At address, participants were asked to replicate a 55% lead foot / 45% trailing foot pattern while a 20% lead foot and 80% trailing foot pressure was desired at transition. Finally, at impact, participants were asked to apply 80% pressure to the lead foot and 20% pressure to the trailing foot. These values were used across all clubs and were recommended by the pressure mat distributor. After in-depth information about the different positions and weight pressure, participants engaged in 30-minute sessions on the mat. Throughout the process, participants were given feedback about their pressure distribution after each shot and were provided with information about how to attain the desired levels on subsequent shots. After working on the pressure distributions and trajectories for 30 minutes, participants were asked to hit the 40 shots and provide the pressure traces described above. Data collection for weeks 2, 3, and 4 followed the same protocol outlined above and took approximately 60 minutes.

Data Analysis

Before analyses, a 'shot value' was calculated for each shot. This measure, which aimed at identifying the participants' best shots, was calculated by subtracting the lateral distance to the center from total yards. For example, if a shot was hit 150 years but was 15 years off center, the shot value was 135 yards. This measure, which is similar to the construct of 'accuracy distance' proposed by Guadagnoli, Holcomb, and Davis (2002), created an objective performance score for each shot based on distance and accuracy. Following the creation of the shot value, all shots were ranked and the best five shots per club were included in the analysis. The best five shots were selected to limit the impact of severely missed shots, which is a common occurrence in novice golfers.

Given that each participant varied in their baseline abilities, it was also important to account for this individual variability in the analysis of results. Therefore, across each week of data collected, performance scores were standardized against week one scores (baseline). Standardized values were calculated with z-scores (see Gravetter & Wallnau, 2000). The standardized scores were then averaged by group to obtain a standardized change score by group (control, instruction, and mat) and time (weeks 1–4).

Following this, 3×4 (group by time) mixed ANOVAs were conducted. Four models were computed to test the differences across the four clubs (9 iron, 5 iron, 3 wood, driver) used in the study. All statistical analyses were conducted using SPSS and the alpha value was set at .05 for all analyses.

Results

Unstandardized average shot values recorded across conditions and clubs are presented in Table 1. These provide general indicators of distances hit throughout the study. When investigating differences of the standardized values, no significant interactions or main effects were found ($p > .05$) across each club. This suggests that there were no differences by group or time in the performance of the players in the current sample. Although there were no significant differences, the obtained data does show some interesting trends. Figure 2 (A—D) represents the performance between groups, over

Table 1. Average Performance (in yards) Between Conditions and Clubs Over Time

	Condition		
	Control	**Pressure mat**	**Instruction**
9 Iron			
Week 1	102	111	102
Week 2	101	119	104
Week 3	102	120	109
Week 4	96	120	106
5 Iron			
Week 1	114	143	119
Week 2	109	150	119
Week 3	113	140	128
Week 4	107	147	124
3 Wood			
Week 1	121	164	135
Week 2	124	176	141
Week 3	128	166	141
Week 4	131	167	146
Driver			
Week 1	145	185	155
Week 2	140	186	159
Week 3	145	191	154
Week 4	142	185	150

time, across the four clubs used in the study. The analyses also revealed that effect sizes (partial eta squared) were very small throughout the study (E.S. range: .04–.16) along with the overall power of the analysis being small (power = .053).

In addition to the analysis of the shot values, pressure trace patterns were recorded between groups over the course of the study. Investigation of pressure traces occurred by looking at the distribution of pressure at address, transition, and impact. Due to video issues throughout the data collection phase, it was impossible to accurately verify the pressure distribution of participants at the transition point. However, pressure information at address and impact are reported in Table 2. Descriptively, it can be observed that at address, pressure patterns were 49/51 (lead/trail) for the control group, 55/45 (lead/trail) for the pressure mat group, and 54/46 (lead/trail) for the instruction group. At impact, overall mean traces between groups show values of 63/37 (lead/trail) for the control group and 77/23 (lead/trail) for the pressure mat and instruction groups.

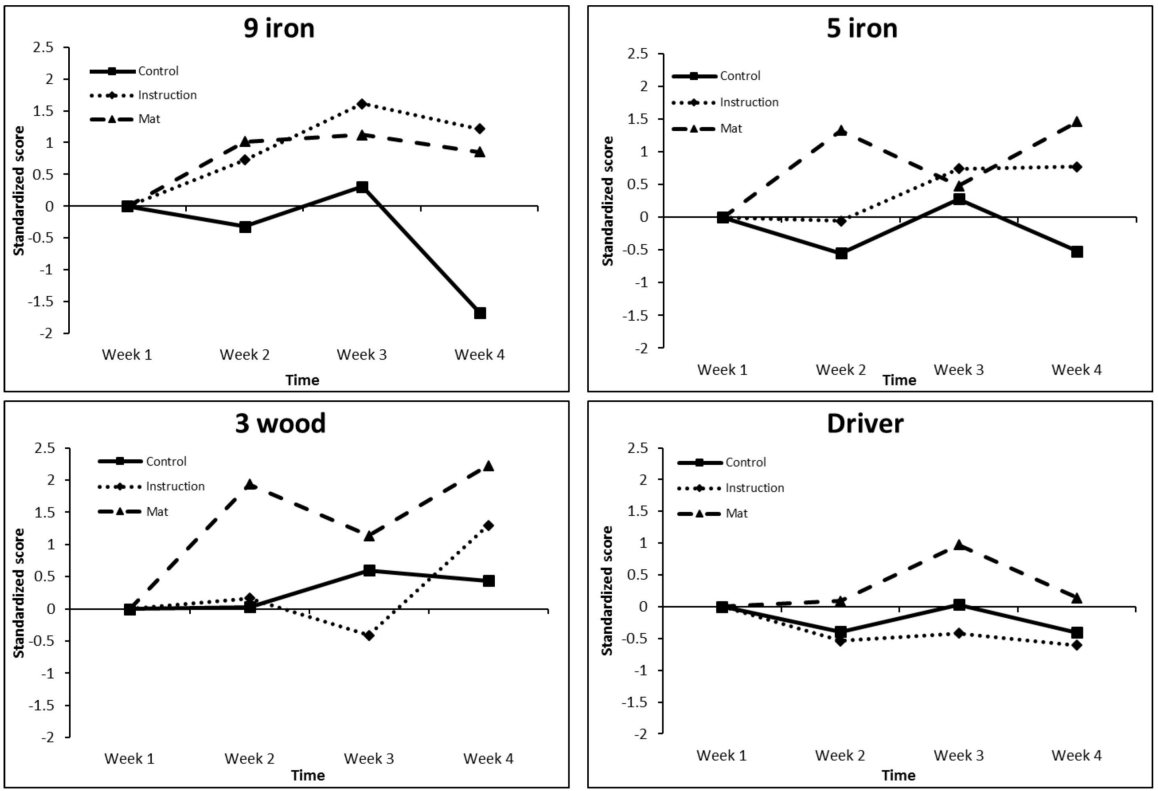


Figure 2 Standardized change score from week 1 to week 4 across the control, instruction, and mat conditions for the 9 iron, 5 iron, 3 wood, and driver

Table 2. Pressure Distribution at Address and Impact Across Time Points, Clubs, and Conditions (C = Control; M = Pressure Mat; I = Instruction). Percentage of Weight Place on Lead Foot Appears First Followed by Trailing Foot (Lead/Trail).

	Address			Impact		
	C	M	I	C	M	I
9 Iron						
Week 1	49/51	56/44	56/44	64/36	76/24	76/24
Week 2	49/51	56/44	57/43	71/29	76/24	84/16
Week 3	51/49	56/44	52/48	66/34	82/18	75/25
Week 4	51/49	58/42	54/46	60/40	84/16	83/17
Average	50/50	56/44	54/46	66/34	79/21	80/20
5 Iron						
Week 1	52/48	52/48	53/47	69/31	70/30	68/32
Week 2	49/51	56/44	58/42	71/29	79/21	78/22
Week 3	49/51	54/46	52/48	66/34	77/23	80/20
Week 4	44/56	56/44	51/49	57/43	77/23	81/19
Average	48/52	55/45	53/47	66/34	76/24	77/23
3 Wood						
Week 1	49/51	53/47	59/41	65/35	73/27	70/30
Week 2	49/51	55/45	53/47	60/40	77/23	80/20
Week 3	49/51	55/45	49/51	58/42	72/28	78/22
Week 4	50/50	59/41	54/46	59/41	72/28	82/18
Average	49/51	56/44	54/46	60/40	73/27	77/23
Driver						
Week 1	52/48	51/49	54/46	61/39	74/26	72/28
Week 2	55/45	56/44	60/40	71/29	84/16	73/27
Week 3	52/48	54/46	53/47	58/42	76/24	74/26
Week 4	52/48	57/43	53/47	55/45	80/20	78/22
Average	49/51	54/46	55/45	61/39	78/22	74/26
Overall Averages	49/51	55/45	54/46	63/37	77/23	77/23

Discussion

The purpose of this study was to examine the impact of a golf pressure mat as a tool for increasing the golf performance of novice golfers compared with a control group and a group who received golf lessons from a certified instructor. It was hypothesized that the golf performance (i.e., shot value) of participants in the pressure mat and

certified instruction groups would be significantly higher than the control group. As can be seen from the results none of the groups differed significantly over time with respect to their golf performance. The secondary purpose was to explore the pressure trace of participants to determine if changes were observed between the groups across the study.

A closer look at the results shows that across all four clubs, the end performance of participants using the pressure mat was higher than their baseline values. These results are similar to the participants who received certified instructions as this group also showed improvements from week one to week four on all clubs except the driver. Conversely, participants in the control group declined in performance from weeks one to four on three of the four clubs (3-wood showed improvement).

Given that individuals in the pressure mat group exhibited performance patterns similar to participants receiving lessons from a certified professional suggests that both methods resulted in similar learning patterns. As mentioned above, these results were not significantly different from the control group, but the trends suggest that performance improvements of similar magnitude may be achievable from practice with the pressure mat or a certified teaching professional.

This information is interesting when we consider it in the framework of practice. As suggested by Lee and Schmidt (2014), PaR practice should focus on planning and reviewing more than repetition. Current results are in line with this proposition in the sense that in both the pressure mat and certified instruction groups participants were spending more time planning and reviewing than the control group. For example, the pressure mat group would receive information about their pressure trace while the certified instruction group would receive technical information about how to properly swing the club. This information forced participants to engage in meaningful reflection and place emphasis on the process of the golf swing rather than repetition. These forms of practice may explain the improvements noted in these conditions and not in the control group. They may also be in line with the hypothesis that random practice is ultimately more beneficial for learning (Schmidt & Wrisberg, 2008); however, further research would be needed to validate this claim.

The results of the current study are also in line with previous research outlining how center of pressure and weight distribution throughout the golf swing can positively affect performance. As shown by Ball and Best (2007, 2012), club head speed and total distance can be positively affected by proper weight distribution. Given that participants in the pressure mat condition improved performance over baseline suggests that paying attention to balance throughout the golf swing has the potential to create more distance (as measured by the shot value in this case). Similar to the point above, additional research is needed to identify the intricate details of this process.

In addition to the information discussed above, the pressure trace patterns observed throughout the study are of interest. When we consider the address position, it is noticed that all groups have a fairly balanced setup. This can be seen with overall averages ranging between 49/51 (lead/trail) to 54/46 (lead/trail) between groups. Alternatively, when we consider the impact position, more variation between groups appears. Namely, the control group has values of 63/37 (lead/trail), while the pressure mat and control group show values of 77/23 (lead/trail). The values of the pressure mat and instruction group align with the developers of the pressure mat recommendations and what was being taught to participants in the pressure mat group. Specifically, participants in

the pressure mat group were asked to apply 80% pressure on the lead foot at impact. Their ability to closely match this number, along with the performance of the instruction group to also match this percentage, could shed light into the performance of the groups. As mentioned, the control group did not have as much pressure on the lead foot at address. These results warrant future research to closely examine if the amount of pressure at impact can significantly affect performance.

Overall, the results of this pilot study are a call for future research examining the role of pressure mats in enhancing golf performance. To do so, future studies should consider the limitations encountered in the current study. First, the sample was small and the amount of time on task was low. With only ten participants in each group, the statistical power of the design was limited. Combined with low power, the effect sizes of the treatment were very small (for discussion of effect size, see Cohen, 1992). With effect size values ranging between .04–.16, it is very unlikely that significant differences between the groups would be obtained with the current sample. To rectify this situation, a power calculation could be computed to determine the appropriate number of participants required. Concurrently, the amount of time using the mat/instruction should be increased as it is clear that learning the complex set of skills required to effectively perform at the task cannot be achieved in such a small amount of time. In the current study, participants engaged in only three 30-minute sessions on the mat or in lessons. This amount of time is minimal when we consider that learning the details of golf is a time-consuming process. Providing participants with longer mat/instructions times could provide the study with larger effect sizes.

Second, it is possible that the participants in the study were not the ideal target population. The group was very novice with almost all participants playing less than 1 round per week (many never play at all). It is possible that players who have higher baseline ability would benefit more from using the pressure mat or receiving lessons compared with individuals who are new to the game. Based on this limitation, it is recommended that a future sample of participants focus on individuals who are more advanced. In addition, it would be of interest to investigate the synergistic effects of the pressure mat and lessons. It is unlikely that both methods would be used independently from one another therefore investigating their combined effects would be a worthwhile endeavor. Finally, a closer analysis of participant's pressure traces over time would be worth investigating to clearly demonstrate if changes in pressure can occur over time.

In conclusion, results of this pilot study provide preliminary information about the ability of a pressure mat in improving golf performance when compared with traditional golf lessons. The findings are in line with the notion that weight transfer is an important component of the golf swing. Although performance changes were not significantly different than the control group, the trends indicate that more research investigating the impact of such instruments in increasing performance is warranted.

Note

1. The author does not have any financial or commercial affiliations with the pressure mat and therefore does not have a conflict of interest in conducting the study. However, the pressure mat was provided by the developers to the researcher to conduct the study.

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