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ARTICLE

Improving Golf Pace of Play Using Time Study Analysis: Influencing Factors on the Green and Tee Box

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Slow play keeps golfers away from the game. Many anecdotal solutions exist; however, pace of play research is lacking in data, specifically time data. This paper presents a time study that analyzes influencing factors of time on the green and tee box. Influencing factors included group size, competition, green type, wind speed, and temperature. Based on the time study results, significant reductions in round length can be achieved. Group sizes of five golfers, compared with groups of four, added fifteen minutes per round in green, and tee box time. Competition, compared with recreational play, added 21 minutes to the round. Other factors that added time were faster greens and higher temperatures. Factors that were not significant in adding to the green time included age, handicap, gender, or green size.

Keywords: pace of play in golf, correlation analysis, work-in-process, throughput

Golf has deep-rooted traditions that are part of its popularity; however, round length is pushing golfers away from the game (Riccio, 2013). At the Arnold Palmer Invitational in 2011, the slowest pace of play while on the green included Kevin Na and Jim Furyk, while Tiger Woods placed fifth slowest on the greens. Kevin Na was the slowest putter, averaging 48 seconds per putt on the greens. Na's counterpart, Jim Furyk placed second slowest on the greens with a 43 seconds per putt average, who has developed the longest putting routine on the Professional Golf Association (PGA) Tour (Diamond, 2011). Slow play has become a norm within the modern game due to this relationship:

Jack Nicklaus + TV + Big Money = Slow Play (Peper, 2014)

Many amateurs mimic the elaborate putting routines of PGA players on television who show no urgency on the green while studying the break from all the angles.

For recreational golf, pace of play is problematic to golf as a business. On a private course, 40 minutes avoided during a round of golf can mean the difference between frustration and enjoyment (Muirhead, 2013). According to the National

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Golf Foundation, the total time that it takes to play a round of golf is a primary factor that adversely impacts the overall enjoyment of the game and discourages participation of more golfers to enter the game of golf. Ninety-one percent of serious golfers are perturbed by slow play on the golf course and also feel that it detracts from their total golf experience. Furthermore, seventy percent of golfers believe that the pace has worsened over time. In addition, more than fifty percent have acknowledged walking off the course due to the frustration of round length (National Golf Foundation, 2012).

Although not all studies agree with his report, the difference between a four-hour and a five-hour round adds up to 64 rounds lost on a busy Saturday potentially costing a public golf course $3,000—$5,000, according to a report by Hueber and Warzala (2010), former president and CEO of the National Golf Foundation. The total number of golfers has declined since 2000. According to the National Golf Foundation and the Sporting Goods Manufacturers Association, the number dropped from an estimated 30 million to roughly 26 million. This decline seems to be occurring very heavily among golfers that play twenty-five times a year or more. Only 4.6 million of this segment of golfers played in 2005 compared with 6.9 million in 2000, representing a decline of approximately thirty percent (Vitello, 2008). According to Nager, United States Golf Association (USGA) president, "Research clearly shows that slow play and the amount of time it takes to play a round of golf detract from the overall experience and threaten to drive players away from the game" (Mackin, 2013, 117). Investigating data related to the pace of play will enable course managers to modify policies and procedures to set up a course that permits golfers to move through it more efficiently (Mackin, 2013).

The golfer is just one component within a complex, integrated system that determines pace of play in the game (National Golf Foundation, 2012). Golf course design, course setup, and player management also contribute to lengthier playing times. Pace of play has become a strategic priority for the USGA. In June 2013, the USGA announced an initiative to improve the pace of play for the game of golf. The campaign was entitled "While We're Young", borrowing the iconic line from Rodney Dangerfield's character in the golf classic 1980 film Caddyshack. "While We're Young" features commercials and public service announcements by legends in the sport like Jack Nicklaus, Arnold Palmer, Lee Trevino, Tiger Woods, and Annika Sorenstam. The USGA campaign also included an educational program that focuses on ways to improve the pace of play as well as online resources to support both players and golf facilities in their endeavors (Wei, 2013). The new USGA campaign underscores a commitment to educate golfers and golf facility managers in an enjoyable and engaging manner about all the factors that contribute to pace of play and the active role each golfer can partake in implementing practical solutions to the problem (Wei, 2013).

If the game of golf is going to grow and not stagnate, the total amount of time spent on the course by golfers during a complete round of golf must be addressed. As underscored by Riccio (2012, 2013), there is a necessity to regulate the pace of play on the golf course. Research has delved into queuing simulation models of Kimes and Schruben (2002), Tiger and Salzer (2004), as well as Riccio (2012, 2013), who have uniquely developed queuing models and applied computer simulations to analyze golf's pace of play. The researchers working on the pace of play complications acknowledge that the solutions emerging from the simulation models will only be effective if there is a financial benefit for golf facilities as a business (Mackin, 2013). In addition, queuing models are only as effective as the data used to develop the models, and little research exists concerning time data.

This study utilizes foundational industrial engineering principles and time studies to offer improvements. The findings of this study provide immediate opportunities for pace improvement and lay a theoretical foundation for future research, allowing for the creation of more effective and efficient techniques to understand the requirements for a quicker pace of play.

Literature Review

Golf Pace of Play

Pace of play was not researched systematically until 1992, when Yates and Knuth developed the model of the pace of play that is currently used. Knuth, Senior Director of Handicapping for the USGA, and Yates solved pace of play issues by calculating solutions for improving the pace of play. Knuth and Yates diligently collaborated in implementing what is called the USGA Pace Rating System. The Pace Rating System analyzes the golf course's length, obstacles, and green-to-tee distances to establish the time it takes to play a round of golf at the specific course. The Pace Rating System consistently concludes that a round of golf on a course should be completed in approximately four hours (Bird, Kerstetter, & Schreyer, 2010).

In addition, Yates (2008 and 2013) wrote the Pace of Play Manual for golf that considered the variables that have a direct impact on the pace of play during a round of golf. Yates cites the five causes of slow play that are complex and unique to each course but can be managed: 1) management policies, 2) player behavior, 3) player ability, 4) course maintenance, and 5) course design. Yates' course management approach yielded reduced average round times by approximately 55 minutes, which resulted in improved customer satisfaction and increased revenue.

Although the Pace Rating System has been in effect for over twenty years, slow play continues to exist. One potential reason is that the Pace Rating System does not have enough detail on important variables or address congestion due to variability.

In 2002, Kimes and Schruben conducted a study that began to use data related to understanding the pace of play. The research used the maximum capacity on golf courses by the utilization of simulation models to study the most controllable factors of capacity. They studied the revenue management of golf courses by completing research on tee time intervals. Kimes and Schruben stated, "Golf courses have two strategic levers, round duration control and demand-based pricing, that they can deploy in a revenue management program (p. 111)." This study manipulated the tee time intervals predicated based on the capacity of the individual golf course.

Following this study, Tiger and Salzer (2004) constructed a spreadsheet-based simulation model of daily play. The model represents the variability and relationships influencing the pace of play as measured by throughput and cycle time. The simulation model predicts that most of the waiting time occurs on par-three tee boxes. Alleviating this bottleneck by allowing the following group on par three holes to tee off while the group ahead is walking to the next golf green improved throughput by thirteen percent without increasing the cycle time.

Another study later conducted by Tiger et al. (2010) analyzed golf course service operations management examining significant sources of bottleneck complications and their ensuing impact on the pace of play. The authors also investigated alternative methods to manage the identified bottlenecks to enable the golf course to perform more efficiently.

A 2013 article written by Southard for the USGA Resource Center entitled "10 Ways to Speed Play and Increase Revenue" focused not only on speeding up the play but how golf courses could increase revenue while remaining focused on the speed of play by better understanding delays, tee-shot designs, flow management, and a systems management approach.

Fu and Whitt performed the most recent study on pace of play in 2014. This research used new stochastic queuing models, by developing approximate performance formulas for the models. Fu and Whitt proposed that the models could be used to help design and manage golf courses to control the pace of play. This particular model can be used to examine the consequence of different tee-time intervals and the extraordinary postponements produced by lost balls as well as unusually slow groups. The cycle time of a golf course exemplifies four confounding qualities that are common in many service systems: network structure, heavy-traffic conditions, transient performance and precedence constraints (Fu & Whitt, 2014).

Time Studies Successfully Used In Other Industries

Harper and Mousa (2013) researched the history of time and motion studies that had been developed during the nineteenth century. Time studies began in the 1880s as a means of wage-rate setting by Frederick W. Taylor, who has been regarded as the "father of scientific management" (Harper and Mousa, 2013). Taylor studied the motions of ironworkers, who attempted to "mechanize" motions to maximize efficiency including ergonomics, proper rest, techniques, as well as other variables that pertain to the specific labor within the industry. Frank B. Gilbreth and Lillian M. Gilbreth developed an alternative variation of the time and motion study, which was actually called a time study. The time study assisted in discovering the most efficient avenues to accomplish the best product by the labor force. The time study also contributed to an effectively managed or regulated labor force for the repetitive work, worker gained skill, and knowledge of product/process over time for the specific industry. The introduction of the time study to industries set an expectation to increase production over time by producing more units over time as well as decreasing the time to complete the task while producing more units. Gilbreth's specific time-study methodology has been successfully applied and functional to industries such as banks, cafeterias, department stores, factories, hospitals, housework, libraries, music, as well as numerous other performance activities. Corporations of all shapes and sizes use efficiency studies to improve their performance levels (Harper and Mousa, 2013).

Riccio wrote an additional study that used time studies as well as the implementation of research to improve industry supply chains in 2013. Riccio (2013) adopted the techniques of "factory physics", written by Spearman and Hopp, by utilizing the concepts and relating them to the game of golf. "The science provides a framework for analysis and brings with it some insights into problems and solutions of moving the product (groups of golfers) through a factory (the golf course)" (p.

16). "Factory physics" is comprised of components such as processes, individual operations, work-in-process (WIP) products, throughput time, cycle time, throughput rate, capacity and bottlenecking. For the factory to produce the highest quality product, it is essential that the specific components of "factory physics" function efficiently. Riccio correlates the "factory physics" to supervising a golf course by coordinating management and golfers for the highest quality pace of play for individual courses. Managing the processes by associating each golf hole as an operation, which was performed in series, by properly managing each group on the golf course as a work-in-process product. This became a completed product when the group finished at the end of the round of golf.

Most recently, the USGA sponsored a major recreational time study by giving golfers GPS data loggers (United States Golf Association, 2014). Over five thousands rounds at over 130 golf courses were collected. The mobile GPS devices time stamp location every five seconds; however, the waiting data are mixed with playing data. In addition, putting time will be difficult to identify without detailed course mapping software. Although this study will be very beneficial, more detailed time studies based on our research should be continued in parallel with the USGA's efforts.

Another study utilizing GPS devices, was conducted by Riccio (2014). The research studied 175 American golf courses in the first week of June in 2013. GPS systems were used to measure shot length and the pace of play on 40, 460 eighteen hole rounds. Riccio's research contradicts the belief of modern golfers that golfs pace of play has slowed down. The average round related to the research took 4 hr and 17 min. In addition, there was a great variation of time regarding the course, day of the week, time of day and type of course. According to historical data, golf pace of play as stayed the same for the last 20–30 years.

The following section addresses the methodology used to analyze the "factory physics" that function on the golf green by analyzing the influences of putting on the golf green.

Greens

Methodology

Two different time studies were performed, specific to two locations: greens and tee boxes. For both locations, events occur in series. That is, only one golfer in each group is active, while the others in the group wait for their turn. Events not on the green or tee box were not evaluated for this research; however, future time studies of fairway, rough, bunkers, etc. should be performed.

Golf course clubhouse flyers were posted one week before the scheduled research study. The flyers provided a description of the study and asked golfers if they would consider participating, noting that withdrawal at any time during the data collection was permissible. On the data collection day, golfers were asked to volunteer and to provide additional information by a designated researcher, who was on the first tee box to record demographics, handicap index of the each individual golfer, the individual golfer's years of experience, as well as weather conditions. This was the only time during the research that a researcher communicated to the golfers on the golf course. Furthermore, one researcher associated with the pace of play study was located at each green that was being studied, to observe in close proximity, with an unobstructed vantage point of the golfers and the green. In addition, the researcher observed the golfers and the green in close proximity but not on the green. Each researcher collected data with specified procedures for recording the times of the golfers.

Golf Courses. Six golf courses were researched regarding the green and tee box study. The first course studied was The Farms Golf Club, which is a public course in Dyersburg, Tennessee and was designed by Kevin Tucker. The Farms course had moderate greenside bunkering, greens that were minimally undulated, along with open tee boxes. The research was conducted on Saturday September 27, 2013; and started at 8:00am and concluded at 1:30pm. During the study the course was crowded with golfers due to a stroke play club championship tournament among members.

The second course researched was the Tournament Players Club (TPC) Southwind, which is a private course in Memphis, Tennessee and was originally designed by Donald Ross but was redesigned by Ron Prichard. The TPC Southwind course had more than moderately greenside bunkering, greens that were more than moderately undulated, along with a mix of open and narrow tee boxes. The research was conducted on Saturday, April 16, 2014; and started at 7:00am and concluded at 1:30pm. During the study, golfers were spread throughout the course and were not too close to push groups in front of them.

The third course researched was the Jackson Country Club, which is a private course in Jackson, Tennessee and the course designer is unknown. The research was conducted on Saturday, May 31, 2014; and started at 8:00am and the study concluded at 3:00pm. The Jackson Country Club course had moderate greenside bunkering, greens that were moderately undulated, along with open to narrow tee boxes. During the study, golfers were spread throughout the course and were not too close to push groups in front of them.

The fourth course researched was Dyersburg Municipal Golf Course, which is a public course in Dyersburg, Tennessee and the course designer is unknown. The Dyersburg Municipal had minimal greenside bunkering, greens that were minimally undulated, along with open tee boxes. The research was conducted on Saturday, June 14, 2014; and started at 7:00am and concluded at 1:00pm. During the study, golfers were spread throughout the course and were not too close to push groups in front of them.

The fifth course researched was Victoria National Golf Club, which is a private course in Newburgh, Indiana and is a Tom Fazio design. The Victoria National course had moderate greenside bunkering, greens that were moderately undulated, along with mostly open tee boxes. The research was conducted on Saturday, April 18, 2015; and started at 8:00am and concluded at 1:00pm. During the study, golfers were spread throughout the course and were not too close to push groups in front of them.

The last course researched within this study was the Dalhousie Golf Club, which is a private course in Cape Girardeau, Missouri and is a Nicklaus Design. The Dalhousie Golf course had moderate greenside bunkering, greens that were moderately undulated, along with driving areas that were a mix of open and narrow tee boxes. The research took place on Saturday, May 2, 2015; the first tee time was scheduled for 7:30am and the study concluded at 2:00pm. During the study the course had a steady flow of golfers but not enough to hurry groups in front of them.

Time-study data were collected for thirteen independent variables considered to be influencing factors on the golf green at six golf courses in 2014 and 2015. Table 1 lists the dependent variable, green time, and the independent variables. Green time began when the last golfer in the group stepped onto the green to putt and ended when the pin was put back into the cup. Three hundred fifteen (315) different times were recorded.

Results

The time-study data were analyzed using regression analysis. Initial diagnostics revealed no multicollinearity. Two data points were removed due to extremely high putting times that the authors deemed as outliers. Figures A1 and A2 in the Appendix shows the residual histogram and the standard residuals plotted versus the predicted times, respectively. Both show that residual assumptions of normality and homoscedasticity were met. Table 2 shows the summary statistics, and Figures 1, 2, and 3 show the impact of group size, competition, and green size on green time.

The linear regression analysis results, shown in Table 3, indicate that the overall model is significant at the < .0001 level. Table 4 shows the variables, ranked from most significant to least. The four variables that are **bolded** (Group Size, Competition, Temperature, and Green Speed (Stimpmeter) are significant at 0.10 or less. With an adjusted R square of .46, the variables in this model account for 46% of the change in the time spent on the putting green in this study.

Table 1 Green Study List of Variables

Variable	Type	Description
Green Time (DV)	Continuous	Seconds
Green Size	Continuous	Measured in square feet
Pin Location	Nominal—3 levels	Front, middle, back
Green Speed (Stimpmeter)	Continuous	Stimpmeter rating
Competition	Nominal—2 levels	Yes, no
Green Undulation	Nominal—2 levels	Flat, Hilly
Temperature	Continuous	Degrees Fahrenheit
Wind Speed	Continuous	MPH
Group Size	Integer—5 levels (modeled as continuous)	1, 2, 3, 4, 5
Group Gender	Nominal—3 levels	All male, all female, mixed
Average Group Handicap	Continuous	USGA Handicap Index
Average Group Age	Continuous	Years
Grass Type	Nominal—2 levels	Bermuda, Bent

Table 2 Green Study Descriptive Statistics (*n* = 313)

Variable	Mean (or Frequency)	Standard Deviation
Y1 (seconds)	154	57
Green Size	5820	1254
Group Size	3.6	1.0
Green—Flat	237	
Green—Hilly	76	
Competition? Yes	43	
Competition? No	272	
Green Speed (Stimpmeter)	10	2
Average Age	47	12
Gender—All Male	289	
Gender—All Female	13	
Gender—Mixed	11	
Average Handicap	14.0	7
Green—Bermuda	216	
Green—Bent	97	
Wind Speed	6	4
Temperature (Far)	67	8.0

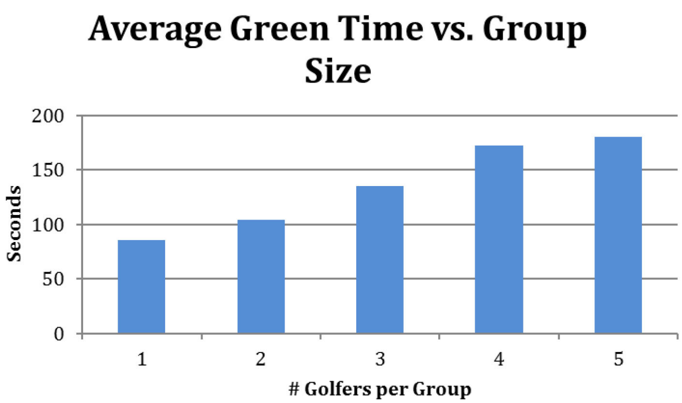

Figure 1 — Average Green Time for Different Group Sizes

Discussion

The coefficient impact is measured in seconds; therefore, increasing **Group Size** by one golfer added 19.4 seconds to the time on each green. **Competition** added 68 seconds to the time on each green. As the temperature increased, green time increased by two seconds for each one degree increase (Fahrenheit). Faster greens,

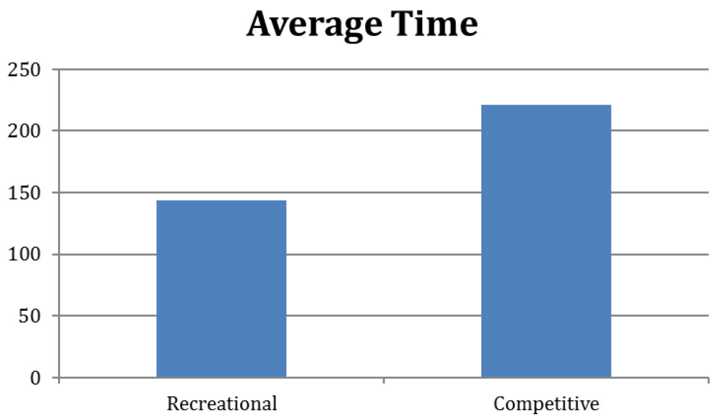

Figure 2 — Average Green Time: Recreational vs. Competitive

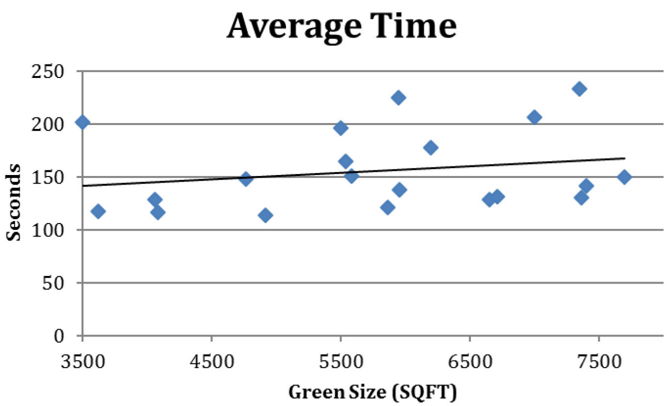

Figure 3 — Average Green Time vs. Green Size

Table 3 Green Study Model Fit

R^2	R^2_{adj}	F	*p*
.48	.46	23.3	< 0.0001

measured by the **Stimpmeter** rating, increased time on each green. For every **Stimpmeter** increase of one, 3.3 seconds was added to each green time. Average handicap, gender, age, and green size did not significantly increase green time.

A larger **Group Size** increased time on the green an additional 19.4 seconds per person. As an example, groups of 5 added almost 6 minutes during a round compared with foursomes, without considering the impact on the tee box, which had a similar impact.

Of the significant variables, **Competition** increases the amount of the time on the green the most compared with the other significant variables. Golfers in a

Table 4 Green Study Coefficients for Model Variables

Variables	Coefficients	Standard Error	t Stat	*p*-value	Significant
Intercept	-79.7	34.4	-2.32	0.02	
Group Size	**19.4**	**3.0**	**6.55**	**0.00**	***
Competition	**68.1**	**10.9**	**6.26**	**0.00**	***
Temp	**2.00**	**0.4**	**5.45**	**0.00**	***
Stimp	**3.34**	**1.6**	**2.10**	**0.04**	**
Avg Handicap	-0.73	0.5	-1.56	0.12	
Wind Speed	-1.41	0.9	-1.56	0.12	
Bermuda	12.4	8.7	1.43	0.15	
Mixed?	17.7	13.5	1.31	0.19	
Average Age	-0.27	0.2	-1.21	0.23	
Women?	-7.44	12.7	-0.59	0.56	
Square Feet	0.001	0.0	0.54	0.59	
Hilly?	1.16	6.5	0.18	0.86	
				Significant	
				0.01	***
				0.05	**
				0.10	*

tournament take significantly more time. Green time increased 68 seconds, which is over 20 minutes per round. The cause of the additional time during competition seems to be related to the conduct of the golfers during stroke play. The golfers were more serious and cautious when reading putts. In addition, every golfer had to putt into the hole for the score to count on the official scorecard; therefore, no golfers picked up the ball on the putting green early due to other golfers conceding the hole.

Hotter days increased putting time. An increased **Temperature** added two seconds per degree Fahrenheit. An increase of 10 degrees would add six minutes per round.

Green speed impacted putting time. Faster greens are more difficult. For a unit increase in the Stimpmeter rating, 3.3 seconds were added. If green speed increased from 8 to an 11, over 9 seconds per green would be added, which is over three minutes per round. Many recreational golf courses are maintaining faster greens (Oatis, 1990) and creating longer rounds.

Tee Boxes

Methodology

Time-study data were collected for nine independent variables considered to be influencing factors on a golf tee box at two golf courses in 2015. Table 5 lists the

Table 5 Tee Box Study List of Variables

Variable	Type	Description
Tee box Time (DV)	Continuous	Seconds
Group Size	Integer—5 levels (modeled as continuous)	1, 2, 3, 4, 5
Mulligans (golfer hits another ball from tee box)	Nominal—2 levels	Yes, no
Par 3	Nominal—2 levels	Yes, no
Walk	Nominal—2 levels	Yes, no
Wind Speed	Continuous	MPH
Women Only	Nominal—2 levels	Yes, no
Temperature	Continuous	Degrees Fahrenheit
Average Group Handicap	Continuous	USGA Handicap Index
Average Group Age	Continuous	Years

dependent variable, tee box time, and the independent variables. Tee box time began when the first golfer in the group stepped onto the tee box or when the group in front was out of the way, whichever time was larger, allowing the golfer to hit when ready. The time ended when the last golfer left the tee box. Two hundred eighty one (281) times were recorded by a designated researcher, who was on the first tee box to record demographics, handicap index of the each individual golfer, the individual golfer's years of experience, as well as weather conditions. This was the only time during the research that a researcher communicated to the golfers on the golf course. Furthermore, one researcher associated with the pace of play study was located at each tee box that was being studied, to observe in close proximity, with an unobstructed vantage point of the golfers and the tee box. In addition, the researcher observed the golfers and the tee box in close proximity but not on the tee box. Each researcher collected data with specified procedures for recording the times of the golfers.

Results

The time-study data were analyzed using regression analysis. Initial diagnostics revealed no multicollinearity or outliers. In the Appendix, Figure A3 shows the residual histogram, and Figure A4 shows the standard residuals plotted versus the predicted times. Both show that residual assumptions of normality and homoscedasticity were met. Table 6 shows the summary statistics, and Figures 4 through 6 show tee box times versus individual variables, group size, women-only groups, and par 3 holes, respectively.

The linear regression analysis results, shown in Table 7, indicate that the overall model is significant at the $< .0001$ level. Table 8 indicates that six variables (Group Size, Mulligans/Re-hit, Par 3, Walkers, Wind Speed and Women Group) generate significant p-values of less than 0.10. With an adjusted R square of .62, the variables in this model account for 62% of the change in the time spent on the tee box in this study.

Table 6 Tee Box Study Descriptive Statistics (*n* = 281)

Variable	Mean (or Frequency)	Standard Deviation
Tee box Time (DV)	137	44
Group Size	3.6	1.0
Mulligans (golfer hits another ball from tee box)	32	
Par 3	76	
Walk	63	
Wind Speed	3.1	2.6
Women Only	15	
Temperature (Degrees Fahrenheit)	64	5
Average Group Handicap	11	5
Average Group Age	48	10

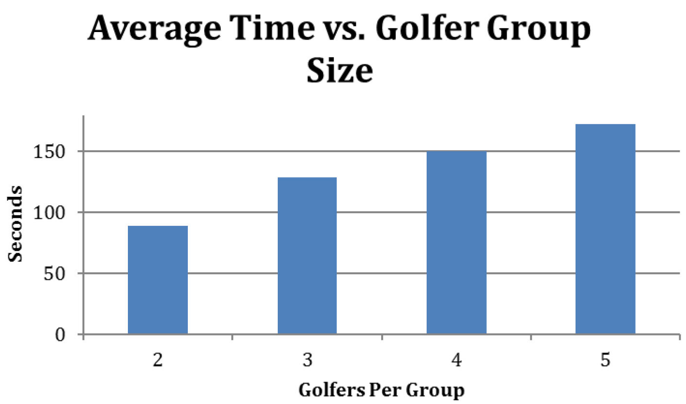

Figure 4 — Average Tee Box Time for Different Group Sizes

Results

The coefficient impact is measured in seconds; therefore, increasing **Group Size** by one golfer added 27.5 seconds to the time on each tee box. **Mulligans/Re-hits** added 58.1 seconds to the time on each tee box. **Par 3** holes added 17.7 seconds due to more time selecting which club to hit. **Walkers** and Women were over 10 seconds faster than **Riders** and **Men**, respectively. For every 1 MPH increase, the tee box time increased by 2.2 seconds. **Age**, **Temperature**, and **Handicap** did not statistically impact tee box time.

A larger **Group Size** increased time on the tee box an additional 27.5 seconds per person. As an example, groups of 5 added over 8 minutes during a round compared with foursomes. Combined with greens, fifteen minutes are added to a round for each increased golfer per group.

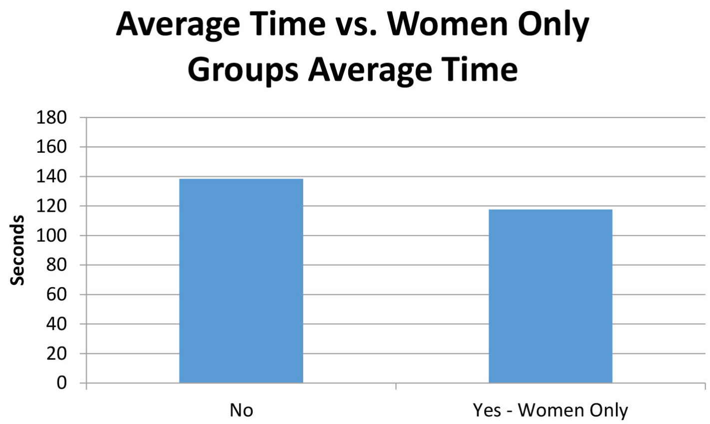

Figure 5 — Average Tee Box Time: Women-Only Groups vs. Other Groups

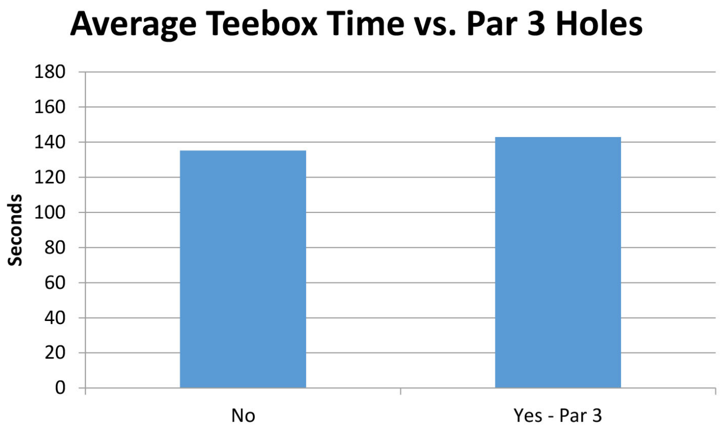

Figure 6 — Average Tee Box Time: Par 3 Holes vs. Par 4 or 5 Holes

Table 7 Tee Box Study Model Fit

R^2	R^2_{adj}	F	*p*
.63	.62	52.0	< 0.0001

Of the significant variables, **Mulligans/Re-hit** increases the amount of the time on the green the most compared with the other significant variables. When golfers hit a second shot from the tee box, an additional minute is added. Although this does not occur on every hole, it does occur quite frequently on the first hole. Sixty-seven percent (67%) of the mulligans/re-hits occurred on the first hole in this study.

Table 8 Tee Box Coefficients for Model Variables

Variables	Coefficients	Standard Error	t Stat	*p*-value	Significant
Intercept	73.3	36.0	2.03	0.043	
Group Size	**27.5**	**1.9**	**14.8**	**0.000**	***
Mulligans (golfer hits another ball from tee box)	**58.1**	**5.3**	**11.0**	**0.000**	***
Par 3	**17.7**	**3.7**	**4.75**	**0.000**	***
Walk	**-11.5**	**4.0**	**-2.86**	**0.004**	***
Wind Speed	**2.2**	**1.3**	**1.75**	**0.081**	*
Women Only	**-13.3**	**7.8**	**-1.69**	**0.091**	*
Average Group Age	-0.23	0.18	-1.32	0.188	
Temperature (Degrees Fahrenheit)	-0.60	0.63	-0.94	0.347	
Average Group Handicap	-0.04	0.41	-0.10	0.919	
			Significant		
				0.01	***
				0.05	**
				0.10	*

Club selection on par 3 holes added an additional 18 seconds. On most par 4 or par 5 holes, the golfer hits a driver. However, different clubs are required on par 3 holes based on its length. Similarly, windier days also significantly increased tee box time.

Types of golfers could also impact tee box time. Women take about 13 seconds less per group. Similarly walkers take about 12 seconds less.

Conclusion

With its romantic history, golf is rich with tradition. Nevertheless, for many, golf is a business that competes with other recreations. The time required to play golf is one of the major obstacles in growing the game. To manage and improve any system, key performance measures must exist and be collected. In our view, basic time data are lacking in golf, and this research is one of the first time studies in the sport of golf.

The purpose of this study is to determine the influencing factors that have significant impact on the putting green. This study complements the USGA "While We're Young" pace of play initiative. For the green time study, the significant linear regression model generated an R^2_{adj} of 46% and identified four significant variables. Furthermore, the highly correlated variables of slow play on the green related to this study are group size (number of golfers in the group), competition (individual stroke play tournament), air temperature, and the speed of the green according to the stimpmeter.

Competitive rounds of golf take significant more time than recreational rounds. When planning a tournament, tournament directors should be careful when making decisions of the number of players to invite and tee time intervals. Similarly group size can significantly length round length. Allowing 5 or more golfers drastically increases the time on the green and tee box.

Some results were surprising. Bermuda greens take longer to putt. Some results were not surprising, but the magnitude of their impact is now quantified.

The tee box study generated an R^2_{adj} of 62% and identified six significant variables and identified six significant variables. Furthermore, the highly correlated variables of slow play on the tee box related to this study are group size (number of golfers in the group), mulligans (re-hit), par 3, golfers that walk the course, wind speed, and groups of women only.

Hopefully, this data-driven study will launch many additional studies, with the ultimate goal of creating a science of golf pace of play. Many extensions exist. Obviously, more data should be collected from more courses than the limited geography and time of year of this study. Time studies of other course features such as bunkers, and fairways should be developed. Data collection technologies should be developed for the golfer and golf course, which would increase the ease of data collection.

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Appendix

Regression Diagnostic Charts

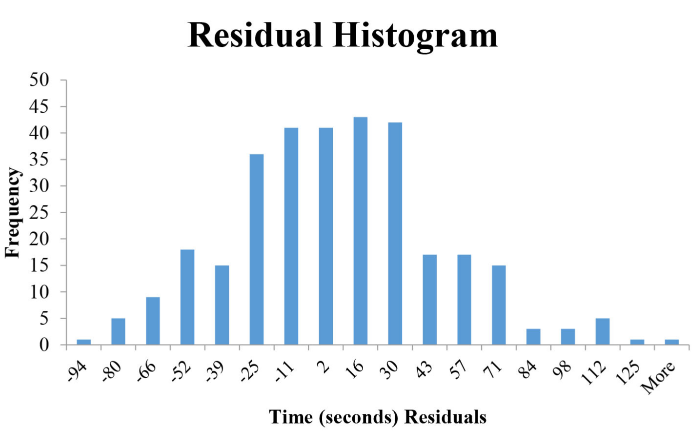

Figure A1. Greens Histogram of Residuals

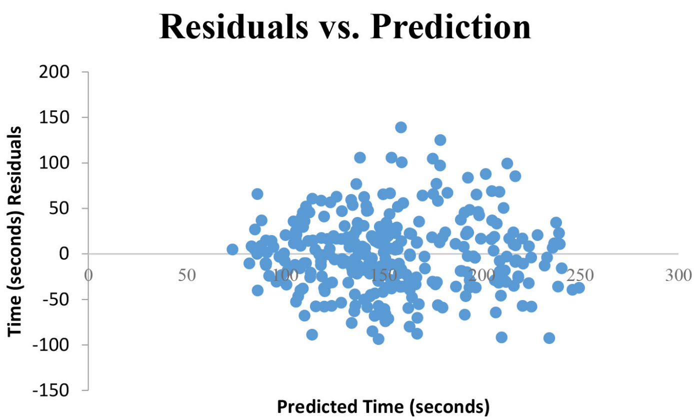

Figure A2. Greens Residuals vs. Predicted Times

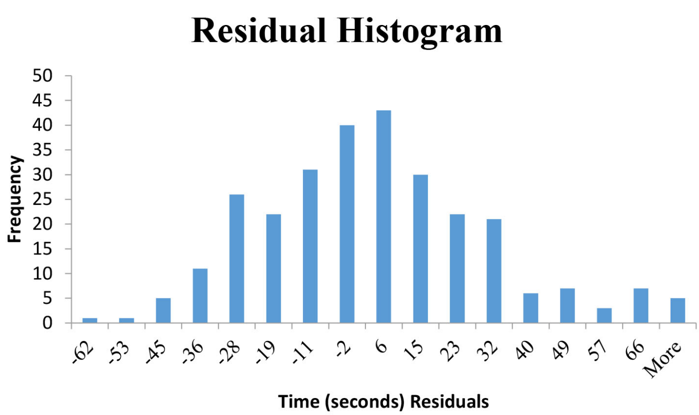

Figure A3. Tee Box Histogram of Residuals

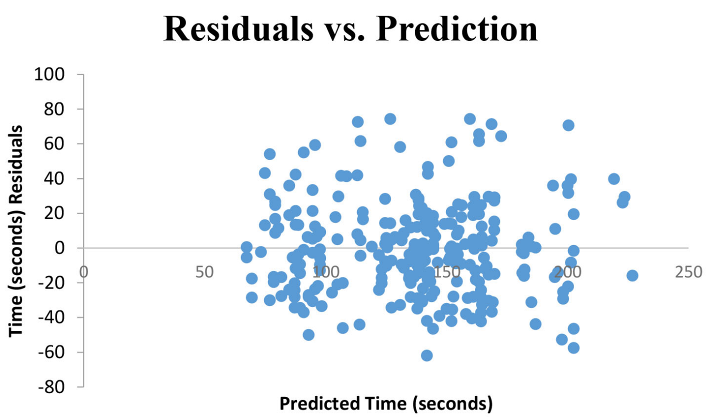

Figure A4. Tee Box Residuals vs. Predicted Times