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A Systematic Pedagogy to Increase Goals to Shots on Goal for Soccer Athletes, *Experimental Design*

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Abstract

UNC Asheville's Women's Soccer season (2011) had the highest number of shots-on-goal in the Big South Conference. However, the ratio of goals scored to shots-on-goal was less than 19.8% which was the lowest percentage of any opponent and significantly below the international average (30%). This two phase research's purpose was to devise a pedagogy that would improve goals to shots-on-goal percentage by targeting the far corner posts rather than the goal's center. Four scorers volunteered to be Phase I subjects (Spring 2012). A split-split plot design was successfully tested. Lessons learned were incorporated into the 2012 season pedagogy (Phase II). Six forwards and mid-fielders volunteered. Of the six, three were freshman who did not play in 2011. The 2012 team result for shots to shots-on-goal was 51% and goals to shots-on-goal improved to 24.2%, which is a 26% increase. Of the three participants in 2011, the combined result was goals to shots-on-goal ratio of 29.5%, which was an improvement of 64%. This result is not significantly different from the international average of 30%. The results from the three subjects who did not participate in 2011 were not significant. Adaptation and refinement of the experimental design and pedagogy is anticipated to result in continued improvements in shots-on-goal to goals for the 2013 season.

Keywords: Soccer, Shot on Goal, Goals Scored, Training Program

1. Introduction

Scoreboards have made it entirely too easy to depict which team is the "better" team, at any point in time, during a sporting event. This is true regarding any sporting competition; whether it is a basketball game, hockey game, baseball game, soccer game, or tennis match. The final score of any competition can be an indication of which team is superior; although, that is not always the most reliable statistic. Many times, the outcome of a soccer game does not truly reflect capabilities of one team over another; and aggregate statistics may be ignored (Skinner, 2009). During the fall 2011 season, UNC Asheville's Women's Soccer program had the highest number of shots on goal (131) than any of the ten other conference teams. However, the percentage of goals scored to shots on goal was only 20%, making it the lowest percentage in the conference. For the average soccer game spectator, it is hard to see past what you are presented; that is

a soccer field, a soccer ball, two teams, 11 players per team, and skill level varying from player to player. While one spectator may define a player as "better", either in terms of fancy footwork, or who throws the ball in farther; there are several factors to take into account when determining which team is respectably the better team. Relying only on the numbers displayed on the scoreboard, inevitably leads to inaccurate assessment and misleading judgment when attempting to understand the games' outcomes. With so many factors that can dictate a player's game performance, numerous studies have been conducted that evaluate different components of a soccer game. Many of these factors may be significant to game results.

Recent studies have examined the effectiveness of factors prominent in a player's performance, the impact of environmental settings on game results, and specifically designed training activities. Specifically designed training activities are a relatively popular methodology in attempt to obtain improvement in various aspects of the game. Several training based activities have been conducted and studied in-depth; however, there has not been an experiment conducted that focused on training activities directly associated with scoring results. The purpose of this research is to develop a training program that will improve the goals scored to shots on goal percentage. The continuous improvement focuses on the players' abilities to aim for the desired target to improve scoring results. Results of studies, in which specific training programs were designed to improve certain skills during game performance, typically showed improvements in the desired areas. A "practice-referenced" framework was used in one study during coaching sessions that focused on defensive aspects of off-the-ball game performance (Harvey, 2010). Both teams that were being observed demonstrated appropriate game responses, in which there was an improvement in numbers in overall game performance. Another study measured the "maximization of displacement" in a natural setting, and a modified setting relevant to elements of a soccer game; and results concluded the natural setting to be equally as effective as the modified setting. The overall performance of improving the measured variable was valid, based on an increase in statistical factors (Coker, 2005).

A study conducted in 2011 was proposed to determine the physical performance characteristics of female soccer players, ages 12-21. Ultimately, "results indicate that female soccer players of different ages have the ability to perform different tasks stronger than another, relevant to their age" (Vescovi, 2011).

The above referenced studies emphasized that there were correlations between variables examined and that the studies' methodologies were relevant to this research project's methodological approach. The variables that were measured in previous studies, specifically overall performance, were directly related to this study's training based methodology. Another factor that is significant in the development of this experiment is the idea of a moving target (goalie) being absent from the goal during the training program. A study conducted used two different strategies: a pursuit strategy and an interception strategy; to observe the affect motion had on a human's ability to reach a desired target (Fagen 2004). When subjects walked through a virtual environment leading the target (interception strategy), they maintained a constant speed walking ahead of the target; which was due to the effort to maintain a direct path using temporary steering dynamics. The pursuit strategy had participants head toward the current position of the target; which manipulated the local and global optic flow of the background. The experiment concluded that this did not influence participants' interception behavior; however, the path was affected by relative motion between the target and background. It can be concluded from the research "that humans use an interception strategy based on the egocentric direction of a moving target" (Fajen 2004). The goal of this research is to develop a training methodology that will improve goals scored to shots on goal. A prototype training program, Phase I (pilot), was developed and tested (spring 2012) to determine the methodology's validity. The results were then used to revise and modify the methodology for implementation during the UNC Asheville fall 2012 season (Phase II).

2. Methodology

The experimental design for Phase I and Phase II is a split-plot design, which were originally developed by Fisher (1925) for use in agricultural experiments. In Phase I, the days were considered as blocks, and there was randomization restriction within each block (or replicate). Upon completion of the three shots from the assigned position the subject randomly rotated to another position to take three more shots. Each replicate or block in the split-plot design is divided into two parts called whole plots and the seasons are called the whole plot. Each whole plot is divided into four parts called subplots and one position is assigned to each. Since the whole plot treatment in a split-plot design is confounded with the whole plots, but the subplot treatments are not; it is best to assign the most interesting factor to the subplots.

Phase II holds consistent with a split-plot design; however, the restrictions were adjusted after making conclusions from Phase I. The main factor (position) in the whole plot is tested against the whole plot error, whereas both the sub-treatment (foot) and the sub-treatment interaction (position*foot) are tested against the subplot error mean square. Notice that there is no test for the block effect.

The analysis of variance for the data is summarized below. Position has a significant effect on the proportion of SOG (455).

Table 1: Analysis of Variance for Split-Plot Design (Phase II)

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Block	5	0.30221595	0.06044319	2.12	0.1046
position	3	0.28907519	0.09635840	3.38	0.0383
Block*position	15	0.27515136	0.01834342	0.64	0.8055
foot	1	0.01343018	0.01343018	0.47	0.5001
foot*position	3	0.15423474	0.05141158	1.81	0.1786

Tests of Hypotheses using the Anova MS for Block*position as an Error Term

Source	*DF*	*Anova SS*	*Mean Square*	*F Value*	*Pr > F*
position	*3*	*0.28907519*	*0.09635840*	*5.25*	*0.0112*

Table 1. Displays the analysis of variance for the split-plot design of the data from Phase II of the training sessions.

2.1 Phase I: Training Program (Pilot)

The pilot study consisted of three training sessions where each subject took three shots on goal from the designated locations: A, B, C, and D. Each location had a specific target (far goal posts), in order to measure the number of shots taken and number of shots on the target (figure 1). Upon completion of the three shots from one assigned position, the subject randomly rotated to another position to take three more shots, then proceeded to do the same for the last two shooting locations.

The procedure was replicated three times for one training session; therefore, each subject took 36 shots in one training session, each of which the location of shooting varied each time. The order in which the subjects participated each session remained the same. The order was changed for each following session. For each session, three shots were taken from locations A, B, C, and D. Locations A and D measured 24.69 meters, and locations B and C measured 16.46 meters. Spots A and B were right footed shots, while spots C and D were left footed shots. The data collector (simulated goalie) stood in the center spot of the 6.706 by 2.438 meter goal frame. The width of the target area measured 1.22 meters from the near left and right post toward the goalie (figure 2) and was marked with caution tape.

2.2 Phase II: Training Program

Changes were made to the program's design in Phase II after suggested adjustments from Phase I. The program now consisted of 6 subjects: three new subjects, all of whom were freshmen; 1 former subject exited and was replaced with a sophomore on the team. Each subject would now take 4 shots from each of the 4 designated locations, rather than 3; and the procedure would only be replicated twice; for a total of 32 shots per training session for each subject. Each location would now include 2 shots with each foot, compared to Phase I, where each location had a designated shooting foot. Measurements hold constant with Phase I.

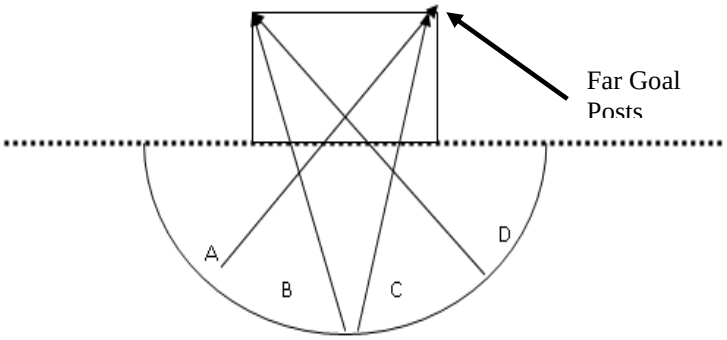

Figure 1: Location Shooting Positions for Shots Taken

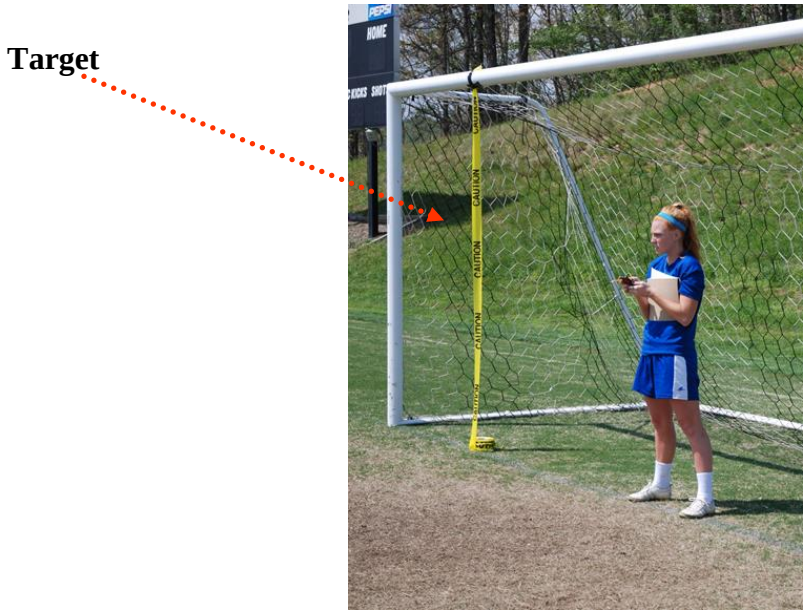

Figure 2: Location of Target and Target Window

2.3 Measuring Ball Speed

The speed of the ball was measured by dividing the number of meters the shot was taken from by the time (seconds) it took from the start of the shot to the time it crossed the goal line. To calibrate this method and instrumentation the radar instructor from the Asheville Police Department used a radar gun to measure ball speed. For shots measured by the radar gun (20 shots) the ball speed was 74.51 km/h. ($\sigma^2 = 12.75$) and the time determined by using a stopwatch (13 shots) was 72.26 km/h. ($\sigma^2 = 65.64$). F-test and Levine's test revealed that the variances were heterogeneous, thus a t-test assuming unequal variances and Satterwaite's Approximation at the 0.05 significance level for unequal variances and sample sizes (Yearout, et. al., 1999) was used to determine that there were no statistically significant differences between the measurements for the two groups. Therefore, the researchers felt confident that the stopwatch method was appropriate.

2.4 Subjects

Four UNCA Women's Soccer athletes between the ages of 18 and 21 volunteered to participate in Phase I of this study. In Phase II, two more subjects were added while one was removed, for a total of 6 UNCA Women's Soccer Players. Each was informed of the study's confidentiality and any risk that might be associated with this project as approved by the university's Intuitional Review Board (IRB). Authors and data collecting assistants have completed CITI (human subjects) Training Program. All signed the appropriate participation consent statement specific to the project.

2.5 Game Data

In Phase I, game data was obtained from the results of the fall 2011 season performance statistics and were not necessarily correlated with a specific subject. Although very useful in determining the validity of the experimental design, it would have to be categorized as notional data. In Phase II, all data from the 2012 season games were used to contribute to data collection, as well as making comparisons between each season's games statistics and training program data.

2.6 Tests for Homogeneity and Normality

All data was subject to tests for normality and homogeneity. The probability of significance (statistical probability of significance differences was $\alpha = 0.05$).

3. Results

3.1 Spring

Tables 2 and 3 represent Phase I and results from the 2011 fall season.

Table 2. Training Program Results

	Subject 1	**Subject 2**	**Subject 3**	**Subject 4**
Shots Taken (S)	72	108	108	108
Shots on Goal (SOG)	36	67	74	86
Goals Made (G)	10	27	33	39
Speed in km/h (σ)	91.5 (22.4)	94.9 (21.2)	97.0 (25.2)	85.3 (19.4)
By Position (SOG/S)				
A	7	15	15	21
B	5	17	26	21
C	14	18	14	25
D	10	17	17	19
By Position (G/SOG)				
A	3	6	7	6
B	3	6	11	10
C	3	8	11	13
D	1	7	4	10

Table 3. Game Result Comparison of Subjects

	Subject 1	**Subject 2**	**Subject 3**	**Subject 4**
Shots Taken (S)	8	8	11	7
Shots on Goal (SOG)	5	4	5	3
Goals Made (G)	1	1	0	0

3.2 Fall

Tables 4 and 5 show the Phase II training program and results from the 2012 fall season.

Table 4. Training Program Results of Subjects

Totals	**Shots**	**Total SOG**	**Total G**	**% SOG**	**% G to SOG**
Subject 1	128	71	29	55.47%	40.85%
Subject 2	112	49	8	43.75%	16.33%
Subject 3	112	70	16	62.50%	22.86%
Subject 4	112	63	32	56.25%	50.79%
Subject 5	192	114	35	59.38%	30.70%
Subject 6	160	88	26	55.00%	29.55%

Table 5. Season Result Comparison of Subjects

	Shots	SOG	Goals	% SOG	% G to SOG
Subject 1	57	25	5	0.44	0.20
Subject 2	29	13	3	0.45	0.23
Subject 3	32	15	4	0.47	0.27
Subject 4	28	14	5	0.50	0.36
Subject 5	56	31	12	0.55	0.39
Subject 6	8	5	1	0.63	0.20

Table 5 clearly displays the team's box scores (total S, SOG, G) for the fall 2012 season. All box score numbers increased from the fall 2011 season. (See Figure 3 for visual representation).

Table 5. Team's Box Scores for 2012 Season

Shots for Season	SOG for Season	G for Season
305	158	38

4. Analysis

4.1 Phase I

For the training program, there were a total of 396 shots (S) taken. Of that total, 263 shots would have been recorded in the game statistics as shots on goal (SOG). The total percentage of shots on goal to shots taken was 0.66 ($\sigma = 0.029$). The percentage of those SOG that were in the target area (goal (G)) was 0.42 ($\sigma = 0.047$). The total percentage of shots in the target area (G) to total shots taken was 0.28 ($\sigma = 0.043$). For the game statistics, the total number of shots taken was 34. Of that total, 17 shots were recorded as SOG. The total percentage of shots on goal to shots taken was 0.50 ($\sigma = 0.121$). The percentage of those SOG that resulted in goals scored was 0.12 ($\sigma = 0.228$). The total percentage of goals scored to total shots was 0.06 ($\sigma = 0.167$). Statistics for both the training sessions and games are listed by subject in table 6.

Two sample proportion tests for SOG examined those that were made from positions A and D (significantly lower) than those that were made from positions B and C (significantly higher) at the statistical significance level (σ) of 0.05.

A simulation of the games lost by one goal determined that a 2% to 6% increase in goals scored based on the same number of SOG had the potential to change seven games lost to victories by one goal. Refer to table 6.

Table 6. Phase I Analysis by Subject

Training	**Subject 1**	**Subject 2**	**Subject 3**	**Subject 4**
% Shots on Goal (SG) (σ)	0.50 (0.059)	0.62 (0.047)	0.69 (0.045)	0.80 (0.039)
% Goals Made: (G) (σ)	0.28 (0.075)	0.40 (0.060)	0.46 (0.058)	0.45 (0.054)
% Goals to Shots (S) (σ)	0.14 (0.041)	0.25 (0.044)	0.31 (0.044)	0.36 (0.046)
Game Statistics	**Subject 1**	**Subject 2**	**Subject 3**	**Subject 4**
% Shots on Goal (SG) (σ)	0.63 (0.171)	0.50 (0.177)	0.46 (0.150)	0.43 (0.187)
% Goals Made: (G) (σ)	0.20 (0.179)	0.25 (0.217)	0.00 (0.000)	0.00 (0.000)
% Goals to Shots (S) (σ)	0.13 (0.117)	0.13(0.117)	0.00 (0.000)	0.00 (0.000)

Thus a 4-15-1 season would have the potential to become an 11-9-0 season. A victory in the one tie was a first round tournament game that was lost in overtime. This would have given the team an opportunity to advance to the

second round of the tournament. This simulation assumes that the opposing team did not increase their number of goals (opponent's goals were held constant).

Of course this training program only dealt with goals scored to shots on goal and did not consider the opponents' defensive performances. Factors such as improved defenses, scouting activities and injuries could not be examined. Much of these factors would be considered during actual team practice prior to and during the fall season.

4.2 Phase II

Between all subjects, they recorded a total of 816 shots (S) in the training program, in which 455 were recorded as shots on goal (SOG). Of those 455, 136 were recorded as goals scored (G), or marked as entering the desired target. For the 2012 season, the 6 subjects recorded 210 shots taken for all games played. Of the 210 shots, 103 were SOG (.49). The number of goals scored for the 6 subjects was 29, making the goals scored to shots on goal ratio 49 percent of their 103 SOG. For the 2012 season, the team's total number of shots taken was 305 (compared to 288 in the 2011 season). The number of the shots taken that were recorded as SOG was 158 (compared to 131 in 2011). The team scored 38 goals for the season, resulting in a ratio of 24 percent for goals scored to shots on goal. In 2011, the team's ratio of shots on goal was .45, and the ratio of goals to shots on goal was .19. The team's shots per game increased 1.7 from 2011 (14.4) to 2012 (16.1). The number of goals scored per game increased from 2011 (1.3) to the goals scored per game in 2012 (2), which is closer to the respectable industrial average (2.5) goals per game.

The 6 subjects scored 76.32% of the team's goals in the 2012 season (See table 7). They recorded 65.19% of the team's shots that were on goal. The 3 returning players accounted for 17 of the 38 goals, alone, which were scored for the 2012 season (See Table 9). In 2011, the 3 returning players scored 42.31% of the team's goals; and accounted for 46.56% of the shots on goal. They scored 11 of the team's 26 goals in 2011 season. Table 9 shows the percentage ratio of the 6 subjects' shots, SOG, and G to the team's data. Table 8 displays the percentage of S, SOG, and G the 3 returning players had out of all subjects.

Table 7. Ratio of 6 Subjects Box Scores to Team Box Scores

2012: 6 Subjects' Statistics to Team Statistics		
% Shots	**% SOG**	**% G**
68.85%	65.19%	76.32%

Table 8. Ratio of 3 Returning Players Box Scores to 6 Subjects Box Scores

2012: Subject 1, 5, 6 Statistics to All 6 Subjects		
% Shots	**% SOG**	**% G**
57.62%	59.22%	58.62%

Table 9. Displays the G and SOG ratio of the returning subjects to the team.

2012: 3 Returning Players Statistics to Team Statistics			
	3 Subjects	**Team**	*% G scored*
Shots on Goal	61	158	38.61%
Goals Scored	17	38	44.74%

Two sample proportion tests for the percent of SOG by all subjects in the training session examined those that were made from shooting locations A and B (significant lower) with the left foot than those that were made from positions C and D (significantly higher) at the statistical significance level (σ) of 0.05. A two sample proportion test was also run for the percent of SOG of all subjects in the training program for the right foot, and those that were made from positions A and B (significantly higher) than the percentage of SOG at locations C and D (significantly lower) at the statistical significance level (σ) of 0.05. Other two sample proportion tests confirmed no significant difference in the percentage of shots on goal for all subjects with the left foot for locations B and C (.48), A and D (.495); as well as with the right foot

at B and C (.51), and A and D (.495). There was also no significant difference in the percentage of goals scored in the training sessions for all subjects. See Table 10 and 11 below.

Table 10: Total Number of Shots on Goal & Goals Scored for All Subjects

SOG	**A**	**B**	**C**	**D**
Left Foot	40	57	65	63
Right Foot	57	71	57	45
total	97	128	122	108
Goals Scored				
Left Foot	8	24	18	13
Right Foot	8	25	26	14
total	16	49	44	27

Table 11 displays the percentage of SOG and Goals Scored from the designated location, per left and right foot in the training sessions.

Table 11: Percent of SOG and G from each location of all subjects in Phase II.

SOG	**A**	**B**	**C**	**D**
Left Foot	41.2%	44.5%	53.3%	58.3%
Right Foot	58.8%	55.5%	46.7%	41.7%
Goals Scored				
Left Foot	50%	49%	40.9%	48.1%
Right Foot	50%	51%	59.1%	51.9%

5. Discussion

5.1 Pilot

From conducting this pilot study, the researchers learned that statistics gleaned from the training program were quite useful. The very large number of shots taken outside of the team's normal practice period and from appropriate field positions that have the potential to yield a higher percentage of goals to shots on goal has very high potential for continuous improvement. It was determined that it would be helpful to have a higher number of participants for Phase II, so there could be more opportunities for shots on goal and goals in a game. The placement of the program shooting positions: A, B, C, and D; were chosen to give each athlete the highest opportunity for a shot to be placed on goal, and to be scored. The major omissions in the game data collection were as follows: prevalent wind direction and speed, field condition information, providing more specific information to the volunteer subjects during study selection, linking sequential program session data with specific game data, and an expanding data collection sheet for game statistics. The revised game data will include: inbounds corner kicks, assists, and other potential instances such as a shot ricocheting back into play after striking one of the forward goal posts or cross-bar, or a goalie losing control of the ball.

Of course the 2% to 2.5% increase by simulation results based upon fall 2011 data would only be realized if the team's mid-field and defenders performance remained constant. However, it does recognize a potential for continuous improvement through a systematic increase in practice shots at a much smaller target that would be more difficult for a goal keeper to block.

The Phase I objective for this study was obtained in that the training program was validated for the study's second phase. Modification of the factors were made for Phase II (fall season 2012) and linked with specific games to practice sessions. Phase II proved to be constant with assumptions made from Phase I. While there was an increase in statistics (shots on goal, goals scored), we assume those results to be from the training program; however, there are outside factors

that could have also lead to the given outcomes. The data used from the fall 2011 season is significant in comparison to the team's offensive performance; although, the defensive performance was inconsistent as expected.

5.2 Actual

Phase II confirmed the researchers assumptions of a 2-6% increase for the UNC Asheville Women's Soccer team's statistics from the 2011 season to the 2012 season. The 6 players that participated in the study contributed to over 65 percent of the team's total shots taken (305), shots on goal (158), and goals scored (38). The total number of shots on goal increased by 27 in 2012 from 2011, offering the team that many more opportunities to score goals. The number of goals scored increased by 12, which is almost half as many that were scored in the 2011 season (26).

In the training program, the numbers of shots on goal and goals scored per right and left foot improved from each location. It was expected that locations B (49) and C (44) would be higher scoring locations than A (16) and D (27) because of their location relevant to the goal.

Adding 3 more subjects to the training program provided the team with greater opportunities to score, contributing to 32% of the team's goals scored for the 2012 season. It is expected that the continued participation of the new subjects and returning subjects into next year's season would increase the team's number of goals scored to 30 percent, which would mean a 6 percent increase from the fall 2012 season.

6. Conclusions and Recommendations

Analysis of the results from Phase I revealed that the training program design did allow room for continuous improvement for an increase in potential goals scored to shots on goal. The experimental design (split-plot) was extremely helpful in stratifying the programs data and making a more verifiable analysis. This phase of the experimental design was also successful in that it revealed some actual game data category weaknesses that resulted in the modification of game data collection during Phase II (fall 2012). To insure that adequate data was collected, the training program for the fall 2012 season was as follows:

a. Increased subject number from four to six front line to mid-field athletes
b. For the first half of the regular season, data was collected once a week
c. Due to travel and other commitments, data was collected only once every two weeks during the second half of the season.
d. Environmental factors were added such as field condition perception and wind direction and velocity.
e. Performance factors were added such as assists and corner kicks.
f. One shot per position was added so that both left and right foot shots could be collected. This will allow 2 shots with the left foot and 2 shots with the right foot per position.

The author fully expected a 2-6 % improvement in goals to shots on goal for the 2012 season. Since soccer is usually low scoring games between relatively equal opponents, such an increase from 20% to 22-26% could significantly raise the team's win-loss record. While the team's win-loss record did not significantly improve, we assume that this is due to the team's defensive performance; as well as opposing team's offensive and defensive performances. However, the results from the training program in Phase II proved to be of significance in the players' abilities to aim for the desired target more efficiently. It was assumed that this year's increase in box scores is directly correlated with the training program; however, factors that are not measured with the training program also affect outcomes. The purpose of the study is to increase the percentage of shots on goal and goals scored, and the data confirms the validity of the training program.

There are several variations of data that could be collected for the training program in the future for implementation that suggests ways the model will offer the most progress in the players' ability to aim for desired targets. Assuming the shooting program will continue the following year (fall 2013 season), box scores will be analyzed in comparison to the data that has already been collected for the 2011 and 2012 seasons; however, data for the actual training program will not be collected. Along with additional shooting outside of team practice, more shooting will also be incorporated into team practices; which will continue to focus on the improvement of aiming for the target that will provide the best chance for a player to score.

Problems encountered during Phase II included field availability due to weather or field conditions, injuries preventing training sessions, team travel schedule, class schedules, and adequate completion time for all sessions. The training program does not account for the number of minutes a player played during a game or averaged during a season; however, that is a variable that could be measured in the future for further implications of a subject's improved performance from the training session. It was also stated that some players had a more difficult time focusing during training sessions when their school work load was heavy, or subjects were tired from team practice or weight-lifting. Any personal matters the subject was dealing with also impacted their mentality during training sessions.

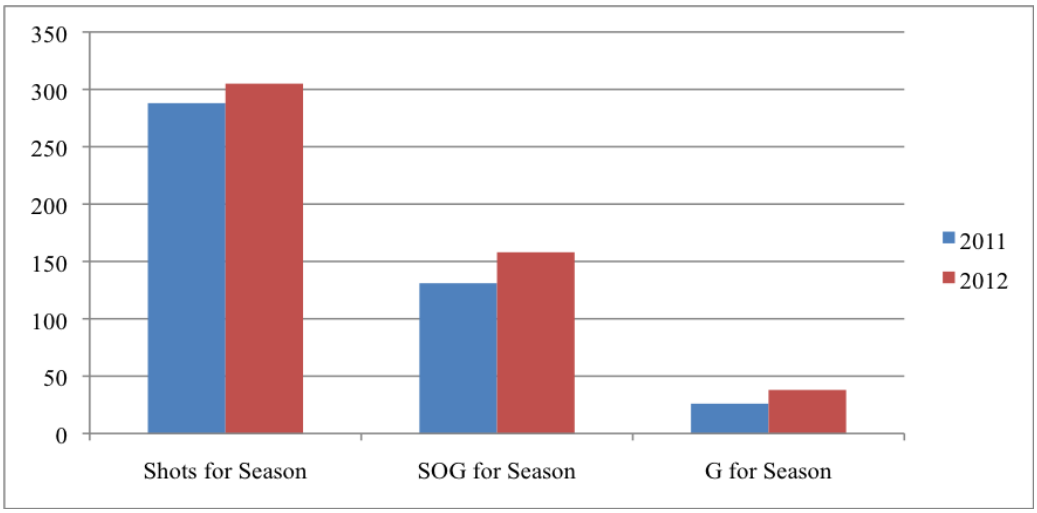

Figure 3: Columns display the increase of shots taken, shots on goal, and goals scored for the UNC Asheville Women's Soccer team during the fall 2012 season.

Figure 3 provides a visual representation of the success the team experienced in their box scores from the 2011 to 2012 season. Ultimately, the specifically-designed training program influenced the players' performances who participated in the experiment. Contributing to more than 75 percent of the goals scored for the season, the program suggests that it allows room for continuous improvement in a player's ability to improve their ability to score; thus influencing the whole team's statistics.

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