# Correlation between PSI of a football and Kicker's Performance

Andrew Bunnell
Burnsville High School
600 E. Hwy 13, Burnsville, MN 55337
Grade: 10 Age: 15
Category of Research: Physical Science
Investigative Research
Advisor: Mike Huemoeller

**Abstract**

The purpose was to see if the PSI of a football would affect the kicking performance of a kicker. Kicking performance being accuracy and distance. If there was less PSI in a football, the football would generally go a less distance because the football would absorb more of the kick. How to measure PSI was looked into to answer the problem as well as how to properly kick the football, and elastic collision. There are certain steps to perform the experiment. The PSI must be measured and properly put into the football. Following that the football was set up for both types of kicking. The kicker took a certain amount of steps for each time and a cone was placed for an even more accurate kick each time. Following those steps, the data was recorded. It showed the PSI did indeed affect distance, the data was significant and there was a correlation. There was not a strong correlation for accuracy. PSI affected distance because of the absorption of energy. The more inflated the football, the farther the football would go. With the 4 sets of PSI recorded, we could make the assumption that for every 2.5 PSI the ball is more inflated, the average distance would increase by about 4 yards. There was no clear reason to why PSI did not affect accuracy, but a reason could be the fact that the way the leg is swung determines the direction of the kick. In conclusion, the hypothesis was supported because the less the PSI was, the average distance did decrease.

## Literature Review

The purpose of the experiment was to determine if kicking a high school football with a lower pounds per square inch (PSI) will affect how far and accurately it can be kicked. Distance is typically measured in yards and accuracy can be measured if it is kicked through the posts. This is important to know because the NFL plays games in all types of weather and if colder temperatures affect how far and accurate it can be kicked coaches and players can make informed decisions on what to do. If you know that in a colder climate, your PSI will drop and that affects your kick maybe you might move your target line closer to the end zone because your accuracy might decrease. To better understand the impact of PSI on football performance in kicking it is important to know what PSI means and how it can be measured, how to kick a football and previous experiments around this topic.

PSI can be measured in a few ways. In order to figure out how to measure PSI, we need to know what it is. PSI stands for pounds per square inch. "PSI is commonly used to measure the pressure of gasses (pneumatic pressure) or liquids (hydraulic pressure). PSI is also used as a measure of tensile strength, defined as resistance to pulling forces, and elastic modulus strength, defined as resistance to deformation, which controls the stiffness of materials." (Rouse, 2017). Most people can generally refer to PSI as how inflated a ball or object is. Measuring PSI is very simple. All you need is a pump that has a gauge. You need to make sure that the gauge is measuring in PSI and not in any other form. After that, you have to check to see the proper PSI of the ball. Normally, the PSI will be written on the ball, but over time it can fade and wear out. Following that step, you have to moisten the needle and put it into the needle hole. It has to go in straight otherwise you are at a risk of bursting the ball. The gauge has to be sensitive enough

to measure the pressure range you require for your ball. Once you have a reading compare your result with your target pressure level, and inflate or deflate your ball accordingly (Latham, 2017). PSI plays a critical role in how the ball is kicked but it is also how the ball is kicked.

Not only can the PSI of a football affect your kick, but it is also the where and how you kick the ball as well. Kicking a field goal involves just a few simple steps. Field goal kicking is when the ball is kicked through the posts. The posts could be both H-shaped or a real post. Either way, the first step is to center yourself. The first step you should take is 3 steps back and after that without turning your body 2 steps to the left (Zodda, 2015). This is how you should take your steps every time. Kickers will use steps and not yards because every kicker is different. As you grow older and taller, the steps will change and adjust how you go. Taking 3 steps toward the ball, you will begin to strike the ball at the proper place. The final step is the follow through. You do not want to swing your leg across your body. Try to keep it straight and by doing that, there should be enough momentum to generate a skip through, which will cause the ball to go higher. Kickoffs occur at the end of touchdowns once the team has just scored. NFL kickers in 2018 have kicked a distance between 58-65 yards (Football Database, 2018). Kickoffs include just 2 main differences between field goals. The first difference is the steps. The steps will be 6 steps back and 3 steps left. The other difference is how you land which is instead of rocking or skipping, you want to try and land on the kicking foot. Doing this will allow for a deeper and potentially higher kick. The question is will kicking a deflated football help you achieve that.

When scientists want to answer a question they tend to look at experiments that have already been done similar to the topic. By looking at a previous experiment done on this topic we can see that a deflated football has a significant impact on the height and distance it can be

kicked. If the air pressure in a ball is increased, then the gas within the ball becomes more elastic. Elasticity enables an object to release energy that is received during a collision. This is called an elastic collision. An elastic collision is one where there is no energy to be lost (Jones, 2018). As a result, some of the energy can be turned into sound and heat from the kick. Once the ball has been kicked, the gas within the ball compresses and then expands. In a ball with lower pressure, there will be lower elasticity. With a lower elasticity, the ball is going to absorb much of the force that is given off by the kicker. This might be good to know because if you want to kick a squib kick you can kick at a lower PSI. Squib kicks are not intended to go far. It is just supposed to get a relatively good distance and then stop.

When we know how PSI can be measured and what it is, how to kick a football and how it affects the distance, and previous studies about this topic we can answer the question how does PSI affect a kicker's performance on the field? PSI stands for pounds per square inch and can be measured through a gauge on any inflation device. Kicking a football with the certain amount of steps and how you land can improve the performance at which the ball does. Previous studies showed that lower pressure means that you have a less elastic collision. Because of that the ball is not going to go as far because the ball takes all of the force given by the kick. Therefore, based on the research conducted, if having a lower PSI has been shown to decrease the distance of a kick, then kicking a deflated football will decrease the distance because there is less air pressure to be used in the elastic collision.

## Materials and Methods

This experiment was conducted at 13450 Dakota Ave Savage, MN 55378. The kicks all occurred at this location. There were four Wilson TDY 1714 footballs used in the experiment.

First, the four footballs were all measured to the standard PSI of 12. Once completed, each football was placed in the fridge at a different temperature. The four temperatures that the ball was placed in was 46, 43, 38, and 35 degrees Fahrenheit. Each ball was inside the fridge for 1 hour. The PSI of each ball was then measured and recorded.

Each ball was set to the PSI. It was marked with masking tape and a sharpie with letters A, B, C, D. A being over-inflated to D completely under-inflated. See Appendix A. Before each kick had taken place the football's PSI was measured. Each football was kicked 50 times. The first variable we measured for was accuracy. This was tested by kicking the football through the uprights. The independent variable was the PSI the football was kicked at. The dependent variable the whether or not the football made it through. The footballs were all kicked from the 25-yard line kicking towards the highway. The kicks that were attempted were 35-yard field goals which are a little bit over NFL extra point. The kicks were attempted in a random order. There was parental supervision during the kicks. There was no wind during the field goal kicking. Before the kick, the PSI was set to the measure that had been recorded. A 2-inch block was placed on the 25-yard line. The football then was placed on top of the block at a completely 90-degree angle held up by a tripod field goal holder. See Appendix B. The kicker then took three steps back and without changing direction went two steps left/right depending on what foot you kick with. These steps were taken once and a cone was placed at the starting position. Every kick occurred from that exact location. Once in the proper position, the plant foot stepped first followed by kicking leg and then plant foot and kick. Those steps were repeated 50 times in total for the four different PSI that was measured. The data was collected by a yes(1) or no(0) answer of whether the kick made it through the uprights.

The next set of kicks were the kickoffs. The independent variable was the PSI of each football. The dependent variable was the distance at which the ball was kicked. These were kicked on the goal line and kicking away from the highway. Each kick was taken from a 2-inch tee at a completely vertical angle. See Appendix C. The plant foot was placed a next to the tee and from there seven steps were taken back and then three steps laterally. After that was completed, a cone was placed directly in the front of the plant foot. The plant foot was the start of the kick and then three walking steps lead into the sprint for the kicking of the football. A total of 7 steps were taken each time during the kick. The data was measured off of the first bounce. An assistant stood on the side of the kick at a distance of 35 yards from the kickoff. Once the assistant spotted where the first bounce occurred, he measured the yard line because the kick was taken at the goal line or zero. The number was then recorded in the data sheet.

## Results

The experiment conducted at the Savage Dome yielded the following t-test scores for distance and accuracy. The t-test was calculated using the Social Science Statistics, with a 0.05 level of significance. The critical value used for all of the calculations were 1.677. The t-test was done between the standard PSI (12) and the overinflated (14.5) had a critical value of 3.57814. The t-test performed between the Standard PSI and the slightly under-inflated (9.5) had a critical value of 3.31. A t-test was also done for the standard and the under-inflated football (7) and had a critical value of 7.36232. The t-test scores are shown in Appendix D. The means for the distance kicking was 57.98 for overinflated, 54.76 for standard, 50.96 for slightly under inflated, and completely under inflated had a mean of 45.12. The medians in the same order as above were 57, 54, 52.5, and 47. Keeping that same order, the standard deviations for distance kicking

were 7.545093198, 7.461482794, 8.851154793, and 9.588320101. The accuracy for the football kicking was at 100% with an over-inflated football and the standard PSI was 98%. The slightly underinflated accuracy performance rested at 92%. The underinflated football had an accuracy rating of 84%. The table for the data showing the mean, median and standard deviation are in Appendix E. All of the recorded (raw) data is in Appendix F.

## Discussion

The purpose of this experiment was to determine if kicking a high school football at a lower PSI would affect the kicker's performance on distance and accuracy. If having a lower PSI has been shown to decrease the distance of a kick, then kicking a deflated football will increase the distance because there is less air pressure to be used in the elastic collisions. For the testing of distance, the t-value was higher than the p-value that was recorded with 49 degrees of freedom and 0.05 level of significance, therefore the results that occurred because of the distance has to be significant. The hypothesis was then supported by the test data.

These results seem logical for one main reason. Previous experiments that were done on this topic are showing similar results. As well as this experiment, other experiments on this topic showed the same results. One test would be the test done by Karen Mode at Clemson University. Their experiment can be found in the bibliography. It shows that the ball kicks best when it is actually overinflated. Unfortunately, there was no significant correlation between the accuracy and the PSI of the football. The only way for the accuracy to have been affect was if the swinging of the leg was changed. To see the field goal accuracy data, see Appendix G.

There was one main reason for the results that were shown. The averages for kickoff are in Appendix E. The reason is that because there was a larger PSI  the elasticity in the ball was

higher and therefore it aided the distance the ball was kicked. If the ball was to be kicked at a higher PSI, the foot hitting the ball would be more like a hammer just smashing it with the ball. The football would use the power given from the leg without absorbing it to move the football. When the ball was kicked at a lower PSI, the ball absorbs much more of the force given off by the kicker and as a result, the ball went a significant amount of yards less the lower the PSI was. The data shows that for every 2.5 PSI decrease in a football, the TDY 1714 footballs average distance decreased by about 4 yards. When the final products and averages are all graphed, the decline between PSI and distance and accuracy is clearly visible. See Appendix H.

The results are important to the field of American Football. Coaches can use this information when deciding what football to use when kicking. If they had a penalty the previous play of a Kickoff and need to kick the football further to reach the end zone, they can use an over-inflated football to help with this. This can also help inform others what happens when a ball is to not be inflated properly. Using this information, we can say that a deflated football must have other better effects on throwing. When the New England Patriots were caught cheating with the Deflategate, the data shows that this did not help them with their kicking performance. The only field goal made during this point was a 21-yard field goal which is much shorter than what Gostkowski can actually make (ESPN). This means that the only reason for them to actually deflate the footballs would have to be with throwing and receiving performance which would lead to a different experiment with the question Effects of PSI on Quarterbacks Performance (Accuracy, Spiral Ability, and Distance) All the data was expected to show up during the experiment.

There were a few sources of error during the experiment. One was the swinging of my leg and how it hit the ball. In order to have the most accurate results, each kick would have to the exact same strength and hit the exact same spot on the ball. Another error that was controllable was if I took the exact same steps every time. In an attempt to minimize this, a cone was placed on the ground where the kicker would stand for each kick. There were no uncontrollable errors because they were minimized. They were minimized because all the kicks were done in a controlled environment with the same temperature and no wind.

After the tests were complete, it was seen that the hypothesis was supported even though there were a few sources of error during the experiment. Nevertheless, due to the PSI being lower, it affected the elastic collision of the football and as a result the ball went a significant amount less.

**Bibliography**

"2018 NFL Kickoff Statistics | The Football Database." *FootballDB.com*, 2018, www.footballdb.com/stats/stats.html?mode=O. Date accessed September 25, 2018

"How Much Does the Air Pressure within a Football Matter?" *Topics, Sample Papers & Articles Online for Free*, 31 July 2016, studymoose.com/how-much-does-the-air-pressure-within-a-football-matter-essay. Date accessed September 27, 2018

"Impacts and Linear Momentum | Physics | Science." *Khan Academy*, Khan Academy, 2015, www.khanacademy.org/science/physics/linear-momentum/elastic-and-inelastic-collisions Date accessed September 29, 2018

Jones, Andrew Zimmerman. "Elastic Collision Occurs When No Energy Is Lost During the Collision." *ThoughtCo*, ThoughtCo, 11 Jan. 2018 www.thoughtco.com/what-is-elastic-collision-2698742. Date accessed September 29, 2018

"Kicking World Blog." *Kicking World What Are The Best Kicking Balls Comments*, 11 Sept. 2012, www.kickingworld.com/how-to-take-proper-kickoff-steps-before-kicking-a-football/. Date accessed October 1, 2018

Latham, Andrew. "How to Measure the Pressure in a Sports Ball." *SportsRec*, 17 Sept. 2018,

www.sportsrec.com/measure-pressure-sports-ball-8300176.html. Date accessed October 2, 2018

Moede, Karen. “Pressure Kicks: The Effects of Distracting Variables on the Outcome of a Pressure Kick in Division-1 College Football.” *Clemson University, August 8. 2018,* https://tigerprints.clemson.edu/cgi/viewcontent.cgi?article=2903&context=all_theses Date accessed October 2, 2018

Rouse, Margaret. “What Is Pounds per Square Inch (PSI)? - Definition from WhatIs.com.” *WhatIs.com*, Jan. 2017, whatis.techtarget.com/definition/pounds-per-square-inch-PSI. Date accessed October 2, 2018

Tang, Kay. “Which Shoes Are Best for Kicking a Football?” *SportsRec*, 17 Sept. 2018, www.sportsrec.com/473326-which-shoes-are-best-for-kicking-a-football.html. Date accessed October 2, 2018

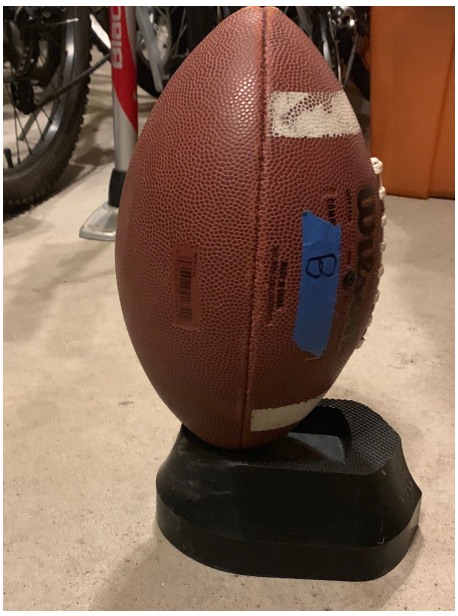
Zodda, Chuck. “Basic Placekicking Technique: How to Kick Field Goals.” *Inside The Pylon*, 2 Nov. 2015, insidethepylon.com/football-101/football-basics/2015/03/02/basic-placekicking-technique-how-to-kick-field-goals/. Date accessed October 5, 2018

Zodda, Chuck. “ITP Glossary: Kickoff.” *Inside The Pylon*, 10 Oct. 2015, insidethepylon.com/football-101/glossary-football-101/2015/10/05/itp-glossary-kickoff/. Date accessed October 6, 2018

# Appendixes

Appendix A

Appendix B



Appendix C

Appendix D

| T-Test Data | | | |
|---|---|---|---|
| | **12 vs 14.5** | **12 vs 9.5** | **12 vs 7** |
| **Distance** | 3.57814 | 3.31 | 7.36232 |
| **Accuracy** | 100% | 92% | 84% |

Appendix E

| | **14.5** | **12** | **9.5** | **7** |
|---|---|---|---|---|
| **Average Distance** | 57.98 | 54.76 | 50.96 | 45.12 |
| **Median** | 57 | 54 | 52.5 | 47 |
| **Standard Deviation** | 7.545093198 | 7.461482794 | 8.851154793 | 9.626963767 |

Appendix F

| Distance | | | | |
|---|---|---|---|---|
| | A | B | C | D |
| Trial | 14.5 | 12 | 9.5 | 7 |
| 1 | 69 | 51 | 57 | 49 |
| 2 | 60 | 53 | 46 | 45 |
| 3 | 59 | 50 | 54 | 23 |
| 4 | 55 | 63 | 48 | 42 |
| 5 | 56 | 57 | 57 | 39 |
| 6 | 57 | 49 | 39 | 47 |
| 7 | 54 | 61 | 54 | 49 |
| 8 | 54 | 54 | 42 | 51 |
| 9 | 56 | 52 | 57 | 47 |
| 10 | 55 | 59 | 48 | 49 |
| 11 | 59 | 57 | 46 | 51 |
| 12 | 58 | 62 | 57 | 53 |
| 13 | 68 | 56 | 42 | 54 |
| 14 | 56 | 55 | 54 | 48 |
| 15 | 54 | 46 | 39 | 47 |
| 16 | 61 | 53 | 50 | 46 |
| 17 | 65 | 59 | 55 | 42 |
| 18 | 55 | 54 | 42 | 43 |
| 19 | 53 | 65 | 57 | 29 |
| 20 | 57 | 58 | 54 | 49 |
| 21 | 66 | 52 | 39 | 35 |

| | | | | |
|---|---|---|---|---|
| 22 | 58 | 54 | 54 | 47 |
| 23 | 59 | 57 | 59 | 54 |
| 24 | 61 | 63 | 47 | 54 |
| 25 | 54 | 55 | 58 | 46 |
| 26 | 68 | 52 | 57 | 49 |
| 27 | 59 | 60 | 52 | 48 |
| 28 | 53 | 58 | 54 | 51 |
| 29 | 57 | 51 | 51 | 35 |
| 30 | 56 | 52 | 50 | 29 |
| 31 | 54 | 56 | 53 | 45 |
| 32 | 67 | 55 | 48 | 49 |
| 33 | 58 | 46 | 52 | 53 |
| 34 | 54 | 53 | 55 | 29 |
| 35 | 53 | 59 | 38 | 57 |
| 36 | 52 | 54 | 45 | 61 |
| 37 | 54 | 48 | 65 | 54 |
| 38 | 62 | 54 | 32 | 52 |
| 39 | 51 | 53 | 45 | 35 |
| 40 | 58 | 51 | 57 | 38 |
| 41 | 55 | 64 | 59 | 43 |
| 42 | 56 | 51 | 53 | 31 |
| 43 | 61 | 58 | 52 | 46 |
| 44 | 59 | 56 | 56 | 51 |
| 45 | 63 | 49 | 57 | 42 |
| 46 | 56 | 52 | 59 | 34 |
| 47 | 54 | 52 | 48 | 42 |
| 48 | 62 | 49 | 51 | 50 |
| 49 | 55 | 54 | 53 | 48 |
| 50 | 63 | 56 | 51 | 45 |

Appendix G

| Field Goal Accuracy | | | | |
|---|---|---|---|---|
| 1=Yes 0 = No | | | | |
| | A | B | C | D |
| Trial | 14.5 | 12 | 9.5 | 7 |
| 1 | 1 | 1 | 1 | 1 |
| 2 | 1 | 1 | 1 | 1 |
| 3 | 1 | 1 | 1 | 0 |
| 4 | 1 | 1 | 1 | 1 |
| 5 | 1 | 1 | 1 | 1 |
| 6 | 1 | 1 | 1 | 1 |
| 7 | 1 | 1 | 1 | 1 |
| 8 | 1 | 1 | 1 | 1 |
| 9 | 1 | 1 | 1 | 1 |
| 10 | 1 | 1 | 1 | 0 |
| 11 | 1 | 1 | 0 | 0 |
| 12 | 1 | 1 | 1 | 1 |
| 13 | 1 | 1 | 1 | 0 |
| 14 | 1 | 1 | 1 | 1 |
| 15 | 1 | 1 | 1 | 1 |
| 16 | 1 | 1 | 0 | 0 |
| 17 | 1 | 1 | 1 | 1 |
| 18 | 1 | 1 | 1 | 1 |
| 19 | 1 | 1 | 1 | 1 |
| 20 | 1 | 1 | 1 | 1 |
| 21 | 1 | 1 | 1 | 1 |
| 22 | 1 | 1 | 1 | 1 |
| 23 | 1 | 1 | 1 | 1 |
| 24 | 1 | 1 | 1 | 1 |
| 25 | 1 | 1 | 1 | 1 |
| 26 | 1 | 1 | 1 | 1 |
| 27 | 1 | 1 | 1 | 1 |
| 28 | 1 | 1 | 1 | 1 |
| 29 | 1 | 1 | 0 | 0 |

| | | | | |
|---|---|---|---|---|
| 30 | 1 | 1 | 1 | 1 |
| 31 | 1 | 1 | 1 | 1 |
| 32 | 1 | 1 | 1 | 1 |
| 33 | 1 | 1 | 1 | 1 |
| 34 | 1 | 1 | 1 | 1 |
| 35 | 1 | 1 | 1 | 1 |
| 36 | 1 | 1 | 1 | 1 |
| 37 | 1 | 1 | 1 | 1 |
| 38 | 1 | 1 | 1 | 1 |
| 39 | 1 | 1 | 1 | 1 |
| 40 | 1 | 1 | 1 | 1 |
| 41 | 1 | 1 | 1 | 1 |
| 42 | 1 | 1 | 1 | 1 |
| 43 | 1 | 1 | 1 | 1 |
| 44 | 1 | 0 | 0 | 0 |
| 45 | 1 | 1 | 1 | 1 |
| 46 | 1 | 1 | 1 | 1 |
| 47 | 1 | 1 | 1 | 1 |
| 48 | 1 | 1 | 1 | 1 |
| 49 | 1 | 1 | 1 | 0 |
| 50 | 1 | 1 | 1 | 1 |
| %Accuracy | 100 | 98 | 92 | 84 |

Appendix H