Grip pressure and the ball flight laws - The myth of the baby bird

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Abstract

The myth of the baby bird is a reference to Sam Sneads old quote giving his idea of how to grip a golf club. For as long as we can remember the teachings of grip pressure have been about loosening your grip – lose your grip and you will get more accurate and longer. We found it to be an interesting idea but we also wanted to confirm it, as we ourselves as teaching professionals are telling players to soften up their grip from time to time. So we asked ourselves – does grip pressure affect the ball flight laws? And if it does is, the looser grip pressure really better?

Going through earlier works from different golf professionals we were unable to find any kind of fact that really supported this urban legend of the golf world. *Muscle strength and golf performance: A critical review* (L Torres-Ronda, L Sánchez-Medina, G Badillo, 2011) instead proves that there is a high correlation between grip strength and lower scores. So we began our own testing. To our aid we had an instrument for measuring a players grip pressure, the SensoGlove. Together with the 3D radar system FlightScope we had the technology to help us keep close track off both grip pressure and ball flight.

After almost 1000 shots were recorded and the data was compiled we are now able to present our result and a long waited answer to our question. To our surprise it is however far from expected. We can in this work present information that supports the straight opposite off what we have been teaching for years. Our results are showing that a majority of the players tested were benefiting far more from tightening their grip. At the same time players whom loosened up on their grip pressure had a decrease in performance all over the board.

A higher grip pressure does not only show to provide a much higher club speed, but also a much more consistent face angle and club path. Theoretically it creates a more consistent centered impact and an easier way to control and be consistent in the angle of attack. All of our recorded data points toward the same result. Most players would become more consistent if they grip the club tighter before they hit it.

With our research we are shedding new light one the question of grip pressure. Our result would be able to change the way we see grip pressure today and possibly make it much more integrated in teaching golf. We are hoping that this work will help shed a light on the importance of grip pressure but also help increase the level of knowledge.

We will change the way we teach grip pressure from now on and our hopes are that we will get others to do the same thing. Also we are leaving some stones unturned and we are hoping that eventually someone will have the drive to help evolve the work even further.

1.0 Introduction

”Grip the club as if you were holding a baby bird” - Most of us have probably heard Sam Sneads famous quote as he tries to describe grip pressure. Ben Hogan allegedly said “What Sam Snead didn’t tell you is that the baby bird is a hawk.”

Have you ever held a baby hawk in your hands? If you are one of those people who have never had the opportunity to do that, how could that comment possibly help you grip the golf club? Now, golf instructors do have the possibility to keep a few canaries in a cage and bring them out as they are going to teach grip pressure. However there are quite a few down sides to that idea. Even if you did you probably would not get any better results.

This is the problem of grip pressure as we see it. Of course we are aware that Sam Snead tried to give word to his own thoughts for other players to understand his way of seeing it. Teaching grip pressure is a rough task and though there are training aids out there we still see problems in it. We do not have the knowledge of grip pressures effect on the golf ball and we do not even know for sure that the grip pressure affects the ball flight.

The LPP-model is bringing us a lot of knowledge of the golf swing. The PGA Teaching Manual (PGA of America, 1990) and the use of laws, principles and preferences is making it possible for us to claim that we know certain things. For instance;

With a club path that is going from the outside and in we actually know that if the club head is straight to the target line, that ball is going to curve right. If a player does not grip the club in his hands nor cock his wrists he is not going to achieve as much club speed as someone who does, there are facts to back that up. We also know that if your club aims far right of your target while your body aims far left at setup, you are going to have a bad time at the golf course. These things we know. They are facts that are taught in the organization of PGA all over the world. Facts that we can use to easier understand both the cause and the eventual effect of the golf swing.

If you were to make a top ten list over the most important parts you need to have in your golf swing, a neutral and relaxed grip would probably end up high on most instructors and players’ lists. Ironically we know that the grip is important for good range of motion, control and eventually a good golf swing. There are hundreds if not thousands of instructions to be read, watched or heard just about a golfers grip. A good amount of which are being quoted in our work.

“As for your grip pressure, keep it light.” (Harvey Penick & Bud Shrake, 1997)
Most of the works are just like Harvey Penicks. In a book of 352 pages grip pressure is just being touched upon briefly as a passing to another chapter or paragraph. Compared to most other parts of the swing grip pressure is getting no room for explanation nor description of how it would affect the golf ball.
Much of what is being said regarding grip pressure simply seems to be assumptions from feelings or own ideas, none of which has got the facts to back it up. Take Sam Sneads famous quote for instance. It is doubtful that Mr. Snead held a baby bird then the club to

check if the pressure in his hands were somewhat similar. Grip pressure is brought up, but is never really explained in terms of how it will affect the ball. Cause in the end we are golfers; we care about what happens to the ball, where it goes and if we can find it again. Without knowing if the grip pressure can help my hook or not, why would I care changing it. If there are no facts for it, no one probably ever will.

1.1 Todays instructions on grip pressure

Grip pressure has been something taught without much knowledge of it. Ideas and feelings have taken over the facts. Our research shows that previous works in the matter exists though being very limited. More often than not the works are being descriptive and not really factual in any way. For instance the PGA Teaching Manual (PGA of America, 1990) reads:

"Grip pressure should be light enough to encourage club head speed without losing directional control; it should be firm enough to keep the club from turning in the hands on contact, yet not so firm that it destroys feel or speed"

It gives us an idea of how it probably should be but no background to why. On a positive side it gives you good descriptions of when you should experience your grip being to tight or to lose. More experienced players or instructors can probably guess from either of the two worst-case scenarios what would happen to the ball. However the statement is not giving us any information on how a looser or firmer grip will actually affect the golf ball.

Now there is a great amount of instructions out there preaching a looser grip pressure for every player, and most instructors probably have done. As we have already mentioned most books refer to grip pressure in a descriptive way and a great majority are underlining the importance of not gripping to tight. Just a few examples of other instructions covering the same point are Tom Watson and Harvey Penick.

"If I could check your grip pressure, I'm pretty sure it would be too tight, and then you wouldn't be able to make a rhythmic swing -- or get your best accuracy and distance." (Tom Watson, Golf Digest 2008)

"As for your grip pressure, keep it light. Arnold Palmer likes to grip the club tightly, but you are not Arnold Palmer."(Harvey Penick & Bud Shrake, May 1999)

The examples are many and most of them are preaching that a loose grip will help the muscles in your arms to relax, making it able for you to hinge your wrists and get what Tom Watson refers to as a rhythmic swing. All in all its being referred to as the best way to create a release for power and accuracy where a real tight grip will instead make the player hit the ball all over the place without control. But there is actually one well-known and very successful male player whom describes himself as the opposite – Jack Nicklaus;

"But if I had to name a pattern, I'd say I'm of the firm-gripping rather than the relaxed-gripping school. And I'd guess that this is probably true of most "legs and body" players as opposed to "hands and arms" golfers." – Jack Nicklaus, Golf My Way, June 2005)

Nicklaus really is saying something out of the ordinary; being the only instructional book we have found actually taking another route than that of the loose grip. But then again he is simply referring to his own golf and he is not actually teaching the reader to grip the club tighter. So a general rule of thumb no matter what is that the best way for golfers to create solid, long and accurate shots consistently is through keeping a rather lose pressure on the golf club through their swing.

1.2 Previous factual works on grip pressure

From a golf point of view it seems impossible to find any works that with facts shows connections between grip pressure and ball flight. Earlier works more based on the physiological part of our golf game has however seemed to found that grip pressure is important to some extent.

"Taken together, and despite that the strength assessment procedures greatly differed between studies, these results suggest that there is a positive correlation between skill (handicap or golf score) and muscle strength, especially grip strength." (L Torres-Ronda, L Sánchez-Medina, G Badillo, 2011)

A correlation between golf score and grip strength could be considered as proof that the grip pressure itself plays a very important role in the game of golf. L Torres-Ronda, L Sánchez-Medina and G Badillos work covers players of a professional status but should be of the same importance to players of all levels. So at least in theory we could see grip pressure as a very important part of the golf swing. But still just proven from a physiological point of view we are unable to see exactly how it can affect a golf player on the course.

The closest, and by far most helpful, previous work in the area we could find was published in IMechE Vol. 222. *Measurement and analysis of grip force during a golf shot* (E R Komi, J R Roberts and S J Rothberg, 2008). It did not only provide a well detailed work of how the grip pressure changes during different segments of the golf swing but also a good general level of knowledge of the biomechanical process of gripping and swinging a golf club.

Even though E R Komi, J R Roberts and S J Rothbergs work really just covers the different grip forces applied to a golf club in the golf swing it really helped us in our work immensely. We were able to learn a lot from it on two different areas, one being the more directly golf related grip force test and the other being their summary of earlier physiological works covering the biomechanics of the golf swing.

Their work with capturing, compiling and comparing the different grip forces of a large amount of players resulted in what they call grip force signatures. Grip force, or which we could call amount of grip pressure applied, here shows acting very similar no difference who the player is or what they are trying to do. This helped us realize that the grip strength of the players we are testing will not be of interest, since the grip pressure will be affected in the same way no matter how high or low the players grip strength actually is. It also worked as proof for us that different motion in the body is directly affecting the possibility of sustaining grip pressure that we used when analyzing the results we got.

"Trends did emerge, such as peaks in grip force just before and after impact, and an overall higher left hand force than right hand was measured for nearly all golfers tested."

The proof of existence of a grip force signature but also their detailed showcasing of how the grip pressure changed during the different segments of the swing was a great time and work saver for us. Getting a good insight in how the grip pressure changed for golfers during their swing gave us a lot of valuable knowledge for our own understanding of how grip pressure is in constant change. Never able to sustain the exact same pressure through the swing.

The summary of their work covers, as we have already mentioned, a lot of works done covering biomechanics of the human body in motion. Their sources gave us a great way to continue our studies and we found their summary to be enough information for our need. It was able to depict how our muscles are being affected strength-wise through moving and how that is related to our grip pressure. In short it is straight up physiologically impossible for a human to sustain the exact same grip pressure or a rather high grip pressure at all through such a complex motion as the golf swing is.

"Additionally, grip and pinch strength vary based on wrist angle"

Finally we had an answer to why grip pressure changes through different part of the swings. Cocking the wrists or a players release is directly affecting a player's capability of gripping the club with full force.

To conclude, previous works in the area are very limited in the sense of practical uses. There are nothing that actually discusses how the golf ball will be affected neither in the more factual works nor the golf instructing ones either. But the few works we could identify actually brings a lot of light to the topic of grip pressure during the golf swing and as we have mentioned will be of uttermost help once we are going evaluating our data to identify a result for our work.

1.3 Grip strength vs. grip pressure

Grip strength is something directly related to our grip pressure. With a stronger grip some of us would probably refer to a left hand grip where the player sees three or four knuckles on the left hand. But no, this time it is all about how strong the muscles that are griping something are. J Hamill and K Knutzen cover the basic biomechanical of humans in their works published in *Biomechanical Basis of Human Movement (2003).* Together with P.A Hume, J Keogh and D Reids work *The role of biomechanics in maximizing distance and accuracy of golf shots (2005), i*s able to provide a somewhat clear picture of how to see a golf grip in action and how grip strength and grip pressure correlates.

As the positioning and tension of the muscles directly affect the strength and grip capabilities of the muscles controlling our grips, grip pressure in a golf swing becomes even more interesting. In short it would make it close to impossible to sustain the exact same grip pressure through out all of the golf swing unless it is more of a chip like movement.

A players max grip strength would in other words be lower at certain points in the swing than others depending on how they are moving their club - as presented by E R Komi, J R Roberts and S J Rothbe in their work. This would at the same time prove that the higher grip strength a player have the higher grip pressure the player can sustain through the swing in comparison to a player with a lower maximum grip strength.

Dr. Greg Rose, co-founder of Titleist Performance Institute, shared some of his experiences from testing grip pressure on the PGA Tour that showed very much the same thing as the biomechanical already showcased.

"Tour players have a much higher maximum grip strength. So a tour player can grip the club lose and still have higher grip pressure than an amateur gripping the club at his max." – Dr.Greg Rose[1]

Together all of these works can show us how the human body reacts and what it can and cannot do. It all correlates; from the works showing that grip strength and lower scores are related to the biomechanical points of what is physically possible to do. Ending with the research done on the PGA Tour by Titleist Performance Institute. So we are going into our own work we do with a good amount of knowledge. However all these works seem to be missing one thing, how it all affects the golf ball!

Finding any earlier works that actually mentions how grip pressure is affecting the golf ball seems to be close to impossible. It is possible that it is seen as trivial and possibly random in the world of golf technique nor that it have been of any interest to find out more about it. Most likely it has to do with technology. Determining with trustable facts what the golf ball is doing in the air at a detailed level have been pretty much impossible until just a few years ago.

[1]Dr. Greg Rose – Co-Founder TPI – Lecture, Stockholm 31/7 2013

2.0 Question formulation and expected results

Does grip pressure affect the ball flight laws? Is the question that we will be using as starting point. So the question is focusing on only one thing, what happens to the ball? There are surely effects in other parts of the body but the full attention of this work will be on the ball flight and which ball flight laws that might change along with grip pressure. The long term goal for our work is to make grip pressure more integrated in golf instructions in the future thanks to a much clearer picture of the correlation between grip pressure and ball flight.

We are in no way trying to identify a perfect grip pressure, as we do not believe such a thing exists. Our goal is instead to find out if, and possibly how, grip pressure affects the ball flight laws and if there is a difference between them. We are expecting to find that different grip pressure is affecting the five different ball flight laws. We are also expecting a looser grip pressure to be more beneficial for most players.

We are expecting a tighter grip pressure to be a hindrance for most players. Limiting the range of motion of the arms and through that making it much harder for players to create a repeatable and efficient golf swing. Making it hard for the player to create golf shots that is not unpredictable and in general hard to play with. We are however expecting the tighter grip pressure to produce a more consistent impact for the player as the tighter grip pressure could suggest it would make it easier for the player to control the golf club.

A looser grip pressure we expect to do the most for the golfer. Relaxed arms and wrists should help them create a higher club head speed through impact. The relaxed body should also make it more likely and easier to repeat the same golf swing over and over again. We are also expecting it to help create a more consistent and similar release of the golf club and club path making the shot more consistent. We are however seeing the looser grip to a possible negative part when it comes to the control of the impact with the higher speeds through impact.

2.1 Definition – Ball Flight Laws

Explaining our definition of grip pressure would seem rather natural as it is on of the major building stones of our work. But so are also the ball flight laws and since we are aware that the term is thrown around pretty loosely we wanted to show our definition of the ball flight laws, as we know them. The ball flight laws are the same ones being presented in the PGA Teaching Manual (PGA of America, 1990) however we have used the modern version of it taught by PGA of Sweden today. This changes the order in which the laws are put and a more detailed name to each law.

Centeredness of hit – *"Centeredness - The exactness with witch the ball makes contact on the face of the club relative to the percussion point or "sweet spot."* (PGA Teaching Manual, p47)

The better centered the impact position the more energy will transfer from the golf club into the golf ball. Thus greatly affecting the distance that the golf ball will travel. A better-centered impact position will also be directly affecting the direction of the golf ball.

Club head Speed – *"Speed – the velocity with which the club head is travelling"* (PGA Teaching Manual, p47)

The higher the speed the more energy the club head brings to the golf ball. This energy will then be converted into the golf ball providing the single biggest factor for producing distance in the golf shot.

Clubface Position – *"Face - The degree at witch the leading edge of the clubface is at right angles to the target line."* (Anders Johansson[2])

The clubface position in impact will be affecting the direction of which the ball starts and will also be affecting the spin of the ball. The clubface position can be either square to target (straight), closed to target (pointing to the same side of the target line as the player) or open to target (pointing to the opposite side of the target line).

Path of the club head – *"Path - The direction of the arc described by the clubhead in its travel away from and then back toward the target."* (PGA Teaching Manual, p47)

Much like the clubface position there are three general ways the club path can follow. Straight to the target line. In to out or inside the target line to outside the target line, crossing the line at impact. Or lastly an out to in path where the club comes from outside the target line going to the inside of the target line, crossing the line at impact. The path of the club head is the major contributor to creating spin and tilting the spin axis in the golf ball.

Angle of approach – *"Angle of approach - The angel formed by the descending or ascending arc of the clubhead on the forward swing in relation to the slope of the ground."* (PGA Teaching Manual, p48)

The angle of approach is directly affecting the launch angle and the amount of spin in the golf ball.

[2] Anders Johansson, Head Coach Training Program PGA of Sweden, Lecture, Carlskrona Golfklubb 4/10/2011

3.0 Delimitations

The biggest delimitation presented to our work is the lack of earlier research in the topic of grip pressure and ball flight. A good amount of extra time had to go into researching and trying to identify useful earlier works to increase our basic knowledge before our own work started. This time could have been better spent collecting more data or further analyzing the data we have.

In our work we are not looking to account for the biomechanics or the movements of the human body in very much detail. We simply believe that the work it would take to depict in a proper way would be too much to justify. Instead we have provided the reader with our sources for what we have used to gather the information we are using and would recommend anyone interested to further their knowledge to follow those links.

We have delimited our questions in order to be able to focus on our work to make sure it keeps a good standard. Therefore we are not trying to find any kind of perfect grip pressure nor try to answer what the best grip pressure would be. We are simply believing that it would be to big of a task to do along with our other research and that proving a perfect grip pressure in a scientific way is near impossible. Also we are not trying to find the best grip pressure depending on level, age or sex of the player. Due to the fact that every golfer is different we are of the belief that we cannot generalize for a whole group of players what is creating the best results. Also due to the sheer amount of work that would have to go into it besides the work we are putting into our main research.

Our work will also not cover the grip pressure in more detailed parts of the golf swing. It will be too big of a stepping stone with the limited knowledge we found in the subject. This could however be a very interesting question for further research.

We chose to use a measuring instrument for the grip pressure that is limited to presenting only the mean grip pressure value of a player. Our work is based on the basic level where we are only interested in whether or not a player have decreased or increased their grip pressure for the full swing. Therefore the measuring instrument is enough for our current level of research.

4.0 Method

Our method was designed through the use of different steps. Firstly choosing the method to gather our data, then compiling the data and eventually analyzing the data to produce a useful result. For the gathering of the data we chose to use an experimental research method where we created a controlled environment for the players we tested. Wherein we had the players manipulate their grip pressure which then would show for us whether or not the variables for the ball flight laws were affected.

To us the grip pressure of the player is what we can define as the independent variable in our research method. For the different variables of the ball flight we call them the dependent variables that we are expecting to show us possible results. (Dr. Price and Dr. Oswald, 2006) In our research we would have participants hit golf balls while manipulating their grip pressure. Our role was to record the dependent variables of the golf ball and golf club to see possible change.

The data we gathered covering the dependent variables we then compiled for the next step in our research. We used data analysis to clean up the data we have gathered and to use the numbers to present a pattern or possible results from our research. We used the data analysis to find averages and deviational values (Joel H. Levine, 1997) of the swings and to identify characteristics of the large amounts of data.

Through our experimental research method and the data analysis we are going to present a result to our question and possibly answer once and for all if grip pressure affects the ball flight laws.

4.1 Materials

Possibly the most challenging part of our method was finding a somewhat easy way of tracking both the grip pressure and the ball flight at the same time but also later being able to link the two. A lot of different ideas were going around but eventually we found an instrument that really would allow us to do just what we wanted, the SensoGlove. For the ball tracking we realized that the only thing that would keep up with the kind of detailed work this was going to be was one of the popular radar systems on the market, we chose the FlightScope.

Our work really revolved around these two parts and barely any ball was hit without the FlightScope and SensoGlove active. At every place tests were being conducted there was a FlightScope present and the player wore the SensoGloves on both hands. The only real difference in these materials at the different locations was different models of the FlightScope radar system. The systems used were one FlightScope Kudo and three FlightScope X2s. However all the FlightScope systems used the latest software.

The FlightScope Kudo in comparison to the X2 model will be about 5% less accurate when it comes to the club data – face angle, club speed, club path and angle of attack. (Jef Carr[3]) Most likely less when used outside where we performed all our testing with it.

[3] Jeff Carr, Director of Sales, Swingcatalyst – e-mail interview 11/12/2013

As we are using the data from the FlightScopes to compare to the same sessions we do not see it as a problem. A player performing our test in the FlightScope Kudo will be hitting all of his or hers shot in that machine. Though four of the given values can vary up to 5% on both sides of the real numbers, it will be present on all shots we are comparing from that system, making the comparison itself still possible.

The testing was being performed at different driving ranges, using driving range balls and range mats. We tried hitting balls off a grass tee but quickly realized that a shot taking a large divot or steep swings that hit the ground first would directly affect the reading of the SensoGloves grip pressure. To create a more controlled environment we decided to keep the testing on the range mats where that problem could be easily avoided. The golf balls that were being used were two-piece range ball kinds from different manufacturers.

4.1.1 FlightScope - Radar System

The FlightScope radar system is by now a well-known name on the market. This system uses radar technology to follow the club head and eventually the ball whilst it is airborne to collect data showing how the club moved and how the ball was affected. The tracking is then showed as different values for the user. These values cover everything from club head speed to the vertical spin. There are a total of twenty-four values displayed by the FlightScope radar system. (FlightScope.com, 2013)

The FlightScope uses a 3-D doppler system to provide us with everything we can think of. It also provides numbers to every value making it a perfect way to compare every different shot to one another. Those exact numbers are what we also matched to the different grip pressures that the SensoGloves provides.

The FlightScope machine in itself uses a computer to communicate with to provide us with the data. The FlightScope software is available on different platforms PC or portable devices such as the iPad. The software differs slightly but provides the user with the same data. For our tests we used both software platforms depending on availability.

All the provided data by the FlightScope is however not purely factual. There are several values that are calculated based on other values provided. The FlightScope radar system has at the same time been proven to be very accurate in its measurements every time and is considered to be very reliable in its shown results. (Jef Carr[4]) As both teaching and playing professionals are using the system in its current form worldwide we see it as reliable enough to be used for our work.

There is a rival on the radar system market for the FlightScope – the TrackMan is by most considered to be a more reliable and in all better machine for its purpose. The use of a TrackMan was never considered for our method as all of us had FlightScopes available. According to Henrik Lundqvist, whom have tested the machines side by side several times, the difference between them is very small.

[4] Jef Carr, Director of Sales Swingcatalyst , e-mail interview 19/11/2013

"I have repeatedly tested my TrackMan side by side to FlightScope… The only thing that stands out is Attack Angle where the results from FlightScope has a larger variation than that of the TrackMan." – Henrik Lundqvist[5]

The information is useful and something we will take into consideration when looking through the numbers. Since our research method will be providing us with a rather large amount of data we believe that the possible miss readings will not be affecting as much. But it will be considered and numbers that seem to be out of the ordinary we will remove from our result.

4.1.2 FlightScope Values

The twenty-four different values the FlightScope system provides us with are useful for different things in a teaching or evaluation situation. However most of them are not necessary for our research. To make things easier for us one of the first steps were to isolate the values that we considered and could prove changed with the grip pressure. That would make it more lucid for both us but also you as a reader having to follow just a few of these twenty-four.

The values we eventually ended up using for our work were decided through the definition of the ball flight laws found in the LPP-model. With the definition of the ball flight laws we then discussed which values we saw as equals to the ball flight laws themselves. We will be covering the definition of the FlightScope-values but also each discussion as to which ball flight law we equaled it to and why.

Smash Factor – *"The ratio between the Ball Speed and the Club Speed" (*mytrackman.com, 2013*)*

Smash factor is the only value of the FlightScope that brings us information on how good or badly centered the impact position of the ball is on the club head. Thus it made it obvious to chose for the correlating value to the ball flight law "Centeredness of hit".

With the possibility to manipulate or rather for the machine to produce a higher or lower than real smash factor number with off center hits due to how it is measuring we had a problem. We were well aware that we could not rely our work nor base any of our work on the smash factor value itself due to this. The only possible solution to the problem that could help us was the use of impact tape. The impact tape would provide us with exact proof of how good or bad a hit was.

However we realized quickly that we could find no efficient way to neither keep track off nor compare hundreds of used impact tapes. Because of that we chose to rely solely on the smash factor value for the ball flight law. Using it as more of a hint of how good or bad the impact position is rather than straight facts.

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[5] Henrik Lundqvist, PGA Professional, e-mail interview 18/11/2013

Club speed – "*Club speed is the linear speed of the club head's center of gravity at first contact with the golf ball" (*mytrackman.com, 2013*)*

Club speed is pretty straightforward and very similar to the ball flight law itself. Thus the pick of this FlightScope value is self-explanatory and did not need much of a discussion. Club speed is also a value taken right from the radar and not calculated in any way, making it a perfect way to evaluate the club speed. The higher the club speed the higher theoretical chance of producing a higher ball speed.

Face Angle – *"The horizontal club face orientation at the center-point of contact between club face and golf ball at the maximum compression of the golf ball" (*mytrackman.com, 2013*)*

Face angle is the most useful value once it comes to determining the clubface position and is only referring to the face angles in reference to the target line. A square face to the target line will be seen as 0.0° while a closed face will be referred to as -1.0° and an open face will be 1.0°. However calculated by the software based off the starting angle of the ball, the club path and angle of attack it is considered to be very accurate.

As the FlightScope provides both the value of Face Angle but value of Face to Path we had to decide which one we considered most exact in correlation with the ball flight law. Since the face angle is the major affecting value to the horizontal starting point of the golf ball and the ball flight law of clubface position itself is referring to position of the clubface to the target line. Thus the face angle value of the flight scope is a closer match to the ball flight law and that was why we chose to use it.

Club Path – *"The horizontal direction of the club head's center of gravity movement at maximum compression of the golf ball" (*mytrackman.com, 2013*)*

Club path is also very similar to the ball flight law itself and another value derived from the real facts coming out of the radar and not calculations. This also made the choice to use it for the ball flight law quite obvious. Just as face angle it is in reference to the target line where a club path going along it will be referred to as 0.0°. A path going from outside to inside will be referred to as -1.0° and a path going inside to out will be 1.0°.

Angle of attack – *"The vertical direction of the club head's center of gravity movement at maximum compression of the golf ball" (*mytrackman.com, 2013*)*

Angle of attack is the closest and pretty much only standalone value able to be used for the ball flight law angle of approach. The FlightScope refers to the ground as zero, where hitting down on the golf ball will create a negative value (-1.0°) and hitting the ball whilst the club is going up as a positive value (1.0°). This too is coming from real facts in the FlightScope machine, however we do have information claiming this value to be differing quite a bit.

Once again the angle of attack is the only real value that could help us define the angle of approach ball flight law. But as we are aware that the FlightScope seem to be varying a bit on the numbers given on that particular value we discussed whether or not it was useful. We saw no other way of measuring and keeping track of the angle of approach other than through the FlightScope and thus we decided that we would have to use it. Angle of approach will then be seen just as smash factor as something that we can not claim is factual results but is a good hint of how the player actually is doing.

4.1.3 SensoGlove

The SensoGlove was the instrument we used for measuring the grip pressure during the players swings. In its original form SensoGlove is a great way for players to control their grip pressure. In its original form the SensoGlove is a training aid for players to learn to control their grip pressure. The player using it will set his desired grip pressure before taking a shot, the Sensoglove will then monitor the grip pressure and if the grip pressure exceeds the set one it will alarm the player. After some contact with David Bauer, one of the creators of SensoGlove, some modifications were made to the original in order to measure the grip pressure of a player on a scale rather than just warn us when the grip pressure was to high.

The SensoGlove uses sensors in four of the hands fingers at detailed pressure points, however not in the thumb of the player. The sensors are connected to a small battery-driven computer on the back of the glove providing a display with both visual and auditory feedback to the player. The sensor measures the pressure on them eighty times per second. Ignoring peaks in the pressure it then provides the player with his or hers grip pressure. This pressure is measured in a scale of 18 to 1 where 18 is almost no pressure at all whilst 1 is as hard as it possibly gets.

The 18 different levels were using an exponential model where on the highest level the increase is much smaller than that on the lower levels. This is done in order to keep the SensoGlove very sensitive when the pressure is low and is able to provide the most detailed information possible. The higher the pressure the more force is needed to increase on the scale that the SensoGlove provides, making it very useful for players with all kinds of grip pressures. (David Bauer[6])

For the use in our research the SensoGlove was starting at grip pressure point zero which would be the number 18 on the exponential model. As the player then hit a shot the grip pressure amount was affected and the mean value of the pressure for that swing presented. The higher the grip pressure the lower the number. This number was the data value which we then noted and matched with the FlightScope-data. The player then simply resets the glove taking it back to starting grip pressure point zero before hitting next shot.

[6] David Bauer, Managing Director of SensoGlove – E-mail interview, 7/9/2013

The SensoGlove is not using any scientific rules when giving the player data through the computer. (David Bauer[7]) Without a scientific model for the grip pressure we were unable to provide a scientific approach to the grip pressure. Thus our work is constantly referring to the grip pressure values provided by the SensoGlove as those are the only real numbers we have got. We are however unable to put a more scientifically recognizable number to it.

The SensoGlove can only provide us with the mean value of every swing a player does. It does not provide us with detailed information on different segments of the swing nor gives us the possibility to see just that. But as we already have knowledge of the grip force signatures affecting the grip pressure in the same way no matter the player (E R Komi, J R Roberts and S J Rothberg, 2008). We believe that the SensoGloves real part in our research was to showcase whether or not a players general grip pressure for a particular swing matched the players intention.

4.1.4 High-speed Cameras

As a part of our research we tried filming a few players we tested with a high-speed camera. The idea behind it was to give us a chance to see whether or not the different grip pressures produced a visually note able change in the players swing technique. Instructions such as Tom Watson (Golf Digest, 2008) had us thinking that a tight grip pressure for example would make the release of the golf club close to impossible. We wanted to get a chance to see whether or not that could be caught by the trained eye when played up in slow motion.

So we filmed two players performing the test. We did not film all shots of the players but a few with each different grip pressure for comparison and as we only had one camera at the location we could only film one angle at a time. But as we believed that the biggest change would be through the impact zone we filmed them mostly from the face-on view. As we had compiled the swings onto a computer and looked through the different swings we tried to identify differences.

To our surprise there were really no obvious changes in the players techniques. We could possibly notice small changes between some swings, but those changes could also be depending on so many other variables than grip pressure. The release that we believed going into it would be a big one was impossible to say how big the changes were, if they even were changing. Debating whether or not it was a valid method for our research we decided it was not.

We saw no good way of proving if the visual changes in the players' technique were due to grip pressure or something else. We also saw no good way of measuring or characterizing the different visual changes. Much of the information we could get out from the video we could also get in numbers from the FlightScope. The camera idea was instead deemed redundant and not used in further testing.

[7] David Bauer, Managing Director of SensoGlove – E-mail interview, 22/12/2013

4.2 Participants

In total we had twenty-one players tested. The players were of different levels, age and sex. The differing level of their game, age and sex were all factors for us to take into consideration. We wanted to have a large pool of players to perform the tests on but we also wanted the pool to spread out when it came to the different demographic variables. Since our question is not focused on one particular kind of players dependent on level of game, sex or age but instead focus on the technique difference as a whole we wanted that spread.

Of the twenty-one players our spread ended up being pretty good for just that. The players were all of different ages, ranging between 21 and 66. Their playing level was very varying to say the least, with a few players being Swedish elite level whilst some just a weekend golfer. A majority of the participants were male and just above a fourth were female. (*Enclosure D*)

All twenty-one players we tested were either students or members from our own golf clubs or players whom we knew very well. Making us able to know a lot of the tested players history of injuries or illness that could have an impact on our result. None of the players we tested were affected by either injury or illness which would render them unfit for participating in our research or supplying good numbers.

There were also six players that we tested but whose numbers would not make it to our research. This was due to either one of two things. Either the FlightScope would not be able to read all the data we needed, this we found on players with a very low swing speed and players whom struggled to get the ball off the ground. Or players would not make the research due to the SensoGlove telling us that the players grip pressure was not changing as intended. We had players whom would apply more grip pressure when instructed not to and vice versa, making the data we gathered useless for our research.

To answer our question we are going to use all the players tested no matter which age group they for instance are in. We are just trying to answer if there is a pattern for all golfers and this would be the way to go about it. Theoretically it could also give us the possibility to see if different test groups show different patterns to their grip change if we would want to check that out.

4.3 Procedure

The procedure we went through to collect was really split up into three different steps. First and foremost we had to try to find a good way to go about the experimental testing we would be doing. Then perform the actual experimental testing with players whom volunteered. Eventually being able to compile the data we gathered through our research making it ready for our analysis.

4.3.1 Work done prior to testing

The first challenge for us was creating a good and effective way to take the players through the tests we were doing. We wanted the testing to be quick and effective in order to make it as simple as possible for the player to understand. But we also needed to make sure that all four of us knew how to compile the data we gathered for all players.

We tried different ways to perform the test on ourselves both to be able to see our own role in it but also see how the players' role would be during the testing. We wanted to find a testing procedure that was simple and we could let any player perform. The test we figured out to be the best was also quite simple, both for us as test leaders and the players themselves.

The testing procedure would have player start by hitting a club ten times with their normal grip pressure and their normal swing. Between every swing they would read off the numbers off the SensoGlove telling the test leader what the grip pressure was. The test leader would then take a note of the grip pressure number and match it to the FlightScope-values. Then the player resets their SensoGloves and makes the next swing. Once ten shots have been recorded this way the test leader instructs the player that the next ten shots will be with either higher or lower than normal grip pressure, and the procedure is repeated. Lastly with the third instructed grip pressure.

Every one of us got to try the role as the test leader and that of the player, to make sure that we were all on the same level and knew what the different roles meant.

4.3.2 Experimental testing procedure

Once ready and confident with how our testing procedure would be performed, we started testing players at our golf clubs. Pretty much anyone was welcome to help us out as we said before; there was no real template the players had to fit. If you could swing a club you had all we needed. With every player we tested we wanted to have detailed data of one or more clubs. We considered it possible that if we had a good amount of different clubs as well as players we could see trends going between clubs.

The two most popular clubs for our testing were the players own 7 irons and drivers, there were no player in our test who hit neither of the two in a session, quite a few hit both. (*Enclosure D*) Other than that a few players also hit a more lofted club, either a pitching wedge or a 9 iron. We also had a few players testing the fairway woods early on but as a few high handicappers was very inconsistent making it hard to get FlightScope numbers we decided to not use it for our research.

A typical testing of a player took from around thirty minutes up to about sixty, depending on a few different factors. During the testing all we did was supervise the equipment to make sure that the SensoGloves and FlightScope did their job. There was no instructions of golf technique involved whatsoever. Our biggest responsibility was taking note of the players grip pressure and keeping track of it. And giving the players instructions of how much grip pressure they should be applying.

First part of the test was explaining the SensoGlove to the players. We would explain how the SensoGlove works and the most important part, how to reset the equipment between each shot. Then the player got to take a few shots "off the record" to get used to the feeling of having the SensoGlove on and swinging with them.

Once the player consider himself or herself used to the gloves and warmed up the testing would commence. Using one of their favorite clubs they would be instructed to hit about ten full shots with that club, just making sure that the SensoGlove records their grip pressure. We as supervisors made sure to note all the grip pressure values they got using their normal swing. We then instructed the player to hit the same amount of balls with the same club but applying more grip pressure through out all of the swing and the procedure is repeated. Lastly we also let the players do the same thing but applying less grip pressure than they would consider their normal.

Continuing the test we repeated the same procedure but let the players try different clubs if time allowed. We had no real template however, for which clubs the players had to test. Instead we thought the most useful results we could get would be if our tests covered as many clubs as possible. But at the same time we would limit the clubs to three each testing session as we wanted the players to be able to hit their full swing with full power each time. We considered hitting more than sixty balls in under an hour would fatigue the player and in that way give us data we could not consider to be accurate.

Some tests were restricted by time and as such not all players were hitting the same amounts of clubs nor the same amount of shots in total. We would therefore consider it most important to have a good amount from one club rather than limited data from several. Thus some players have only hit one club while others had time for several. We never instructed the players to mix grip pressure, for instance griping lose with the left hand and hard with the right hand.

4.4 Compilation of gathered data

When we have tested twenty-one players and had a record of close to one thousand recorded shots we stopped our testing. Even though we had the possibility to continue the testing indoors for a longer time we believed that the 992 shots we had recorded would be plenty for our analysis of the data. But if we found it lacking we would go back to testing players indoors.

As we wanted to be able to see an average off all shots hit but also every single individual shot from all players whilst being able to see the players grip pressure and club hit we based our data compilation in Microsoft Excel. Manually entering every single value from the reports that the FlightScope provided and the noted grip pressure for every shot to get it just the way we saw fit. A tedious, time consuming task that was necessary since none of the measuring instruments were able to present their results in an editable version.

Once we had compiled the data from every player in the FlightScopes sessions we then matched their FlightScope values with recorded grip pressures. This was done through noting every grip pressure during our testing with every shot number in the FlightScope. When everything was in the same Excel-file we used the programs built-in formulas to derive the average value in every FlightScope value and the grip pressure of each hand. The next step was finding the deviation from the average values; this was done through using the standard deviation formula in Excel. Before calculating average and deviation values we removed the highest and lowest result for every different value.

After going through the average and deviation value for all the complete sessions we decided to remove the highest and lowest deviating values for every grip pressure in every session. This was done to take two things into account, the complexity of the golf swing and the possibility of human error. Repeating the same swing over and over again is a challenging task for all players and a nervous or tired player can eventually throw off a whole testing session. As we continuously would see players producing very deviating results in their ten shots we considered this a must.

However the most deviating values were often limited to one or two for each grip pressure. The other numbers would still differ but be much less deviating. We also had to take into consideration that we were testing players of very differing levels and experience. Which meant that some players would vary a lot in their numbers no matter how whilst some of the better players would vary very little instead. We had to find a middle ground to generalize our method and such we did through only removing the best and the worst value from every grip pressure session.

Having both average and deviation values to take part of and evaluate for our result were important in different aspects. Since the five ball flight laws are defined differently so would the definition of what is sought after for each and every one. For instance most players would benefit most from being very consistent with their smash factor rather than having a higher possible average. Thus for the value of smash factor a smaller deviation would be sought for before a higher average, whilst of course an increase together with a small deviation would be the best.

The average and deviation value were showcased first for each club and their specific grip pressure. Then comparing the averages and deviations between different grip pressures with the same golf club and lastly comparing different players average and deviation values with other players. For example a player hits ten shots with his 7 iron and his normal grip pressure, those ten shots are then presented in the Excel-file and the average value is calculated. The ten shots being hit with a higher and lower grip pressure then follow below and eventually a summary of the three different average values and deviation values in every cell.

Our test group ended up with twenty-one players in total. As some players were tested differently the data gathered is different. While some players recorded only thirty shots from one club others would record the same thirty shots with two or three clubs. Rather than comparing players to players we instead considered every club to have its own value, even though it would be the same player hitting it. This decision was made due to the fact that different clubs have different statistical values in the FlightScope. For instance you are most likely striving to hit a 7 iron with a negative attack angle whilst you are striving to hit a drive with a positive attack angle. Making the different clubs producing different values that would throw off our numbers if added together.

Instead we could more easily see if there was a characteristic between players using the same club or if the grip pressure would change. It would also create more stand-alone values to be used for our research. All in all we recorded twenty-one different players and thirty-one different clubs, which ended up in 992 recorded shots which we compiled and later used for our research.

5.0 Results

Our result is based of the averages and deviations from our centered values. We compare the values produced by different grip pressure. This made it possible for us to find trends over all players and identify if there were trends only emerging from a specific part of players. And produced a result to our question based on the facts we gathered through our experimental research.

The data will be presented covering each ball flight law at a time giving detailed information what we have found. We will also cover how we came to the results and chosen the way we have in every different ball flight law. All ball flight laws will be presented with the different grip pressures, their numbers being depicted and our analysis of them.

We are not trying to find the perfect grip pressure in general nor for a specific group of players. We are trying to identify if the grip pressure affect the ball flight laws and how does it affect them if it does. So our result presentation will be focused on providing the information of the changes in the dependent variables as players are changing their independent variables.

5.1 Does grip pressure affect the ball flight laws?

The question of the work is whether or not grip pressure affects the ball flight laws and yes it does. Grip pressure is affecting every single one of the ball flight laws. No player or club could avoid it; grip pressure is affecting the ball flight laws. Our research shows that increasing and decreasing your grip pressure will change how you hit the golf ball. Without spoiling the results of which grip pressure is preferred. Know that we have measured each ball flight law by different parameters to make sure that we are actually looking at an improvement or regression.

The centeredness of hit, clubface position, path of the club head and angle of approach were all looked at from the standard deviation of the values produced. We looked too see a decrease in the deviation which would mark a more consistent player. Thus an improvement in the centeredness of hit would actually be a decrease in the deviational value, because the closer the deviational value is to zero, the better. Club head speed is the only value where we saw to the average value. An increase in the average value is an improvement where a decrease in the average value is a regression for the same player.

With that out of the way, we present our results from our research. A result which, we found to be quite surprising.

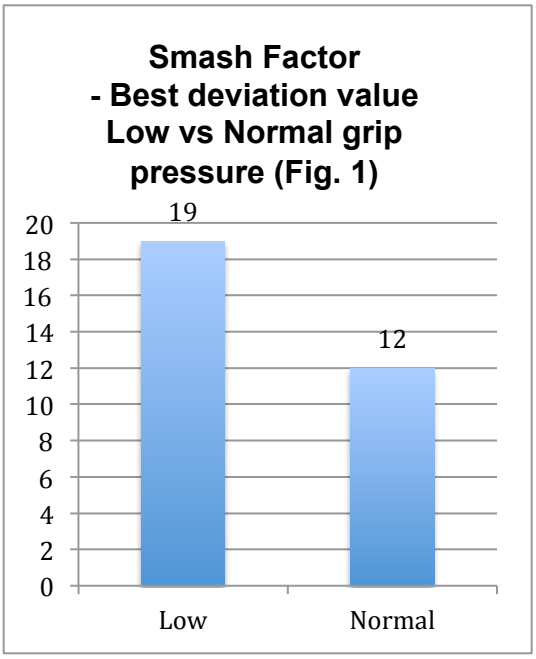
5.2 Centeredness of hit

The centeredness of hit is a value we have based off the FlightScope-value Smash Factor. Unfortunately as none of the radar systems today actually see the face of the club at impact but instead calculate how well centered the hit is this is a value we cannot declare as fact in our result. It is however a good hint of how good the hit would actually be and we do believe that since we are using an average of values it is still worth to account for to cover this ball flight law.

For the centeredness of hit we considered it most important to be consistent. A high smash factor will of course produce more energy into the golf ball, but if the deviation is high the consistency will never be there. For a player to be able to have some kind of idea of how far their clubs go a consistent centeredness of hit is a must. Thus we chose to look mainly of the deviation that players had with their different grip pressures. Of course a higher is not meaningless but if the average went up and the deviation went up we considered it to be a loss rather than if the opposite would have happened.

5.2.1 Low grip pressure

Grip pressure would directly affect the centeredness of hit for all players and all shots. As already mentioned we are looking to find a decrease in the deviation value for the smash factor in order to consider it an improvement. Many of the players decreasing their grip pressure would actually increase their average smash factor value. On the other hand a good amount of those players instead regressed in their deviation value in comparison to what their standard grip pressure produced.

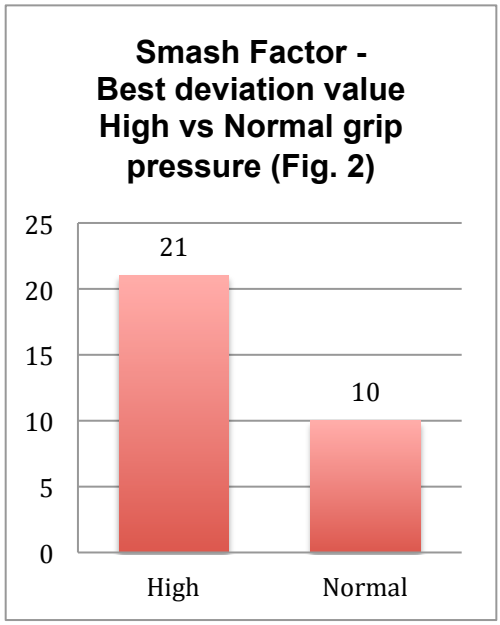


From the 31 different recorded shot sessions there proved to be a majority of players whom improved their smash factors deviation value through loosening the grip. 19 shot sessions were showing that they produced a more solid and consistent ball striking through lowering the grip pressure. The other 12 sessions kept a better deviation value for their smash factor by keeping their grip pressure at normal. (Fig. 1)

Now the lose grip pressure seemed to produce the most deviating values for a few sessions. Where players could produce really good smash factor values on a few shots and some very poor values on others. Possibly due to the FlightScope being manipulated by mishits. Creating a higher average instead but still keeping the deviation value rather unchanged.

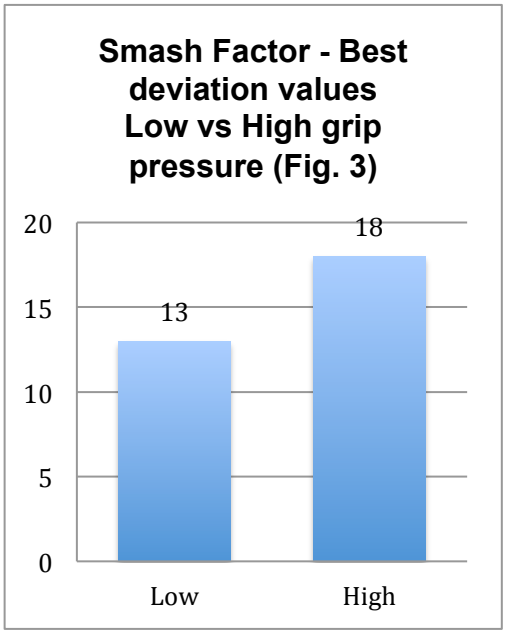
5.2.2 High grip pressure

Just as decreasing grip pressure, increasing it also affected the centeredness of the hit directly. The higher grip pressure creates a much more steady value for twenty-one of the tested sessions (Fig. 2), perhaps not increasing the average value but at the same time removing a lot of the peaks or valleys of the value instead. Ten of these sessions would decrease their deviation in smash factor by 0,05 or more, while they would also increase their average value through doing so.



21 of the 31 sessions proved to produce a better smash factor value when the grip pressure was increased above normal. The last ten tested sessions would still sustain better values through keeping their normal grip pressure. (Fig. 2)

If we instead compare the low and high grip pressure from these sessions the numbers changes a bit. 18 of the 31 sessions are still showing best results with a higher grip pressure. But the numbers have decreased from when we compared it to the normal grip pressure. Now the low grip pressure is producing the better results in 13 of the 31 sessions. (Fig. 3)

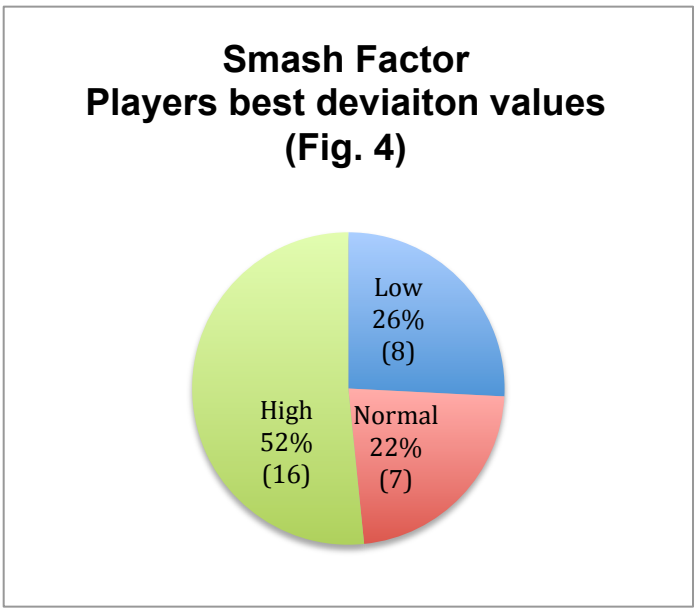


The numbers are pretty even and both increasing and decreasing the grip pressure seems to both be valid options for improving the smash factor of a player. As 19 sessions showed at decrease in grip pressure is more beneficial in comparison to normal (Fig. 1). And 21 sessions showed that a higher grip pressure is beneficial in comparison to normal (Fig. 2). This suggest that players struggling to be consistent with their centeredness of hit could help it through applying more grip pressure.

But if we look to the big picture there are even more things to take into consideration. If we compare all three different grip pressures at once we get a good overview of how they performed. 52% of the players tested had the best showcased values from increasing their grip pressure. While 26% of the players tested showed that the best way for them to be consistent is through lowering their pressure. And the fewest percentage was the normal grip pressure for just 22% of the players.

(Fig 4) A fact that is perhaps surprising but also goes to show that the teaching of grip pressure possibly is a way of finding players unknown source of creating a more consistent golf shot.

The grip pressure affects the centeredness of hit. Our research shows that 78% of the sessions we tested would improve their values of the centeredness of hit through changing the grip pressure from their normal. Only 22% of the tested sessions produced a more reliable impact position with their current normal grip pressure. While 52% of the sessions showed the best values when increasing their grip pressure.



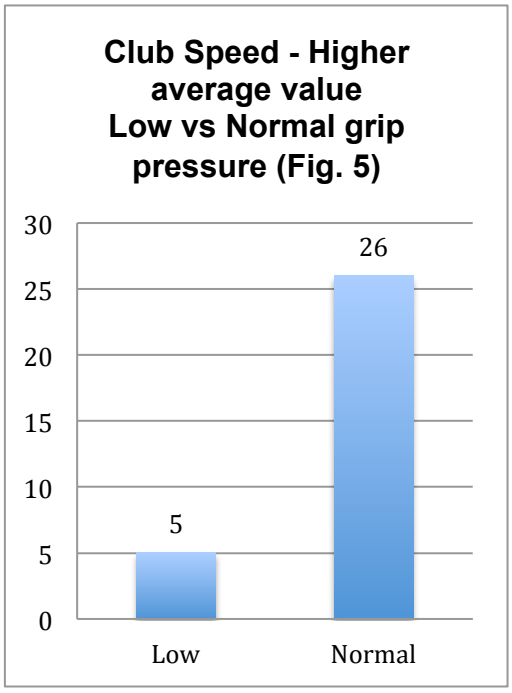
5.3 Club head speed

The FlightScope-value Club Head Speed covered the club speed. A value based off the radars real feedback and non-calculated this is something we really can refer to as facts. Without a doubt club speed is covered under the cliché “the more the merrier” as it in theory means more energy into the golf ball and possibly longer golf shots. Thus we have chosen to focus on the averages provided by the different grip pressures. If the average goes up or down it can directly be defined as an improvement or regression for that session. Considering the high value that Club Head Speed will be having a deviation is looked at in correlation with the average value but is no single value to consider.

For every shot we are revising for our research of the club speed we took the other values into consideration. Even though we are looking into increasing the average we also had to control the face angle and club path to make sure that the shots produced were so crocked that would not be playable.

5.3.1 Low grip pressure

The players loosening their grip pressure is providing interesting numbers for the reading. As the grip loosens most players seem to get a much more inconsistent club speed, some times producing great peaks and other times just slow non-powerful shots. Overall the average of their club speed is decreasing or at best keeping level with their standard values. Creating a rather uncertain and unpredictable golf swing.

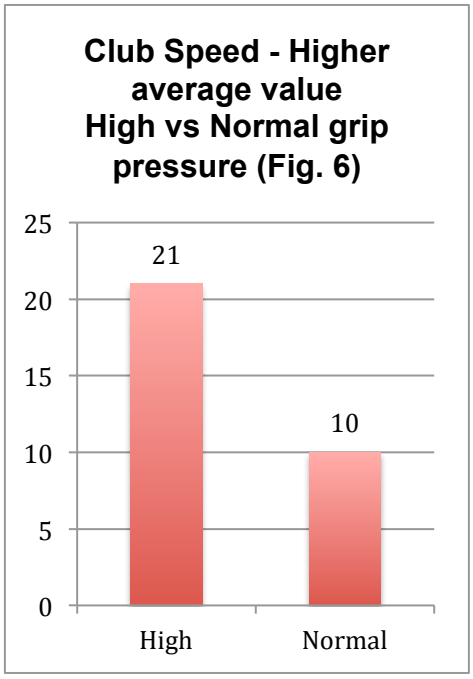


The numbers are showing us a quite clear result. Only 5 out of the 31 sessions produced a higher average club speed value. In the other 26 of the 31 sessions the normal grip pressure were steadily producing a much higher average value. (Fig. 5) The differences presented could some times be as big as seven or eight miles per hour between the two grip pressures.

Now that big a difference would make a big difference on the result of the golf ball. No matter what level of player you are there is a noticeable difference in most of the players we tested. The biggest changes seem to happen to the players with the lower swing speeds. Loosening the pressure for those players shows to be close to fatal, making players whom probably need all the speed they can get lowering it even more.

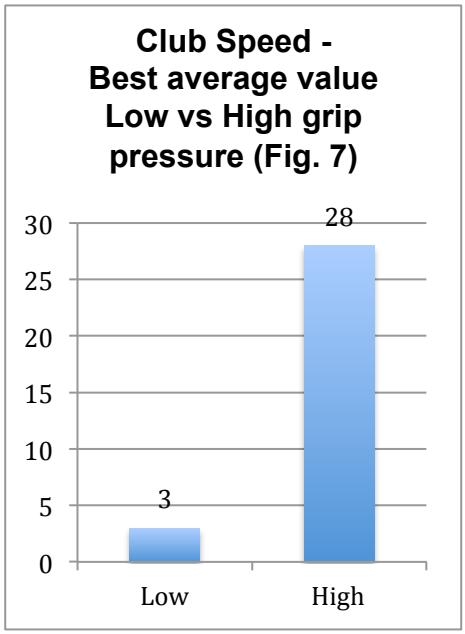
5.3.2 High grip pressure

When the players grip their clubs with a higher force the club speed changes straight away. 21 sessions are showing that a increase in their grip pressure increases their club speed a good bit, not only bringing the peaks up but also the lowest values increasing, creating a higher than standard average value. The sessions also seem to create a smaller deviation in their club speed.



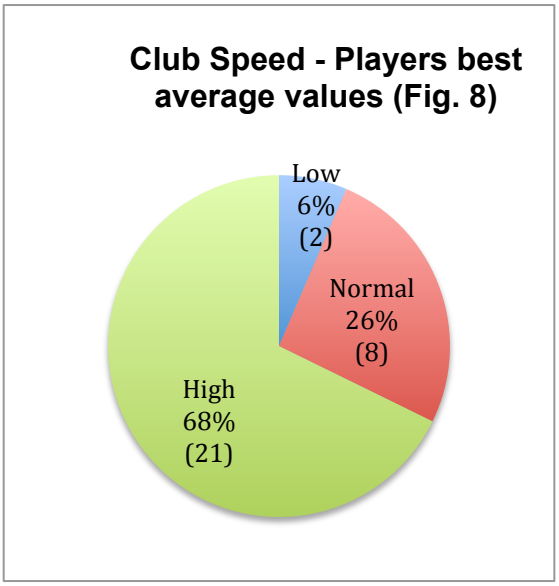
21 out of the 31 sessions are showing an increase in the average club head speed when the grip pressure is increased. While ten sessions are still showing better results with their normal grip pressure. (Fig. 6) The sessions that are producing the increased club speeds are doing so without sacrificing the face angle or the club path, keeping the ball on track. Much like the lower pressure the players whom seem to be most affect are players with slower swing speeds. Some of which show 10% increases at their average, just by increasing grip pressure.

A majority of the sessions showed a better result for the high over the normal grip pressure. When comparing the high grip pressure to the low grip pressure it changes even more. 28 of the 31 sessions improved their average club speed through increasing the grip pressure. Only three out of the performed a better result with a lower grip pressure. (Fig. 7)



For club speed the numbers are talking for themselves. As the normal grip pressure in comparison to the lower one produces better average values for 26 of the 31 sessions. (Fig. 5) And the high grip pressure is increasing that number even further, from 26 to 28 of the 31 sessions. (Fig. 7) We can with certainty say that the more grip pressure a player has the higher the likelihood of a higher club speed.

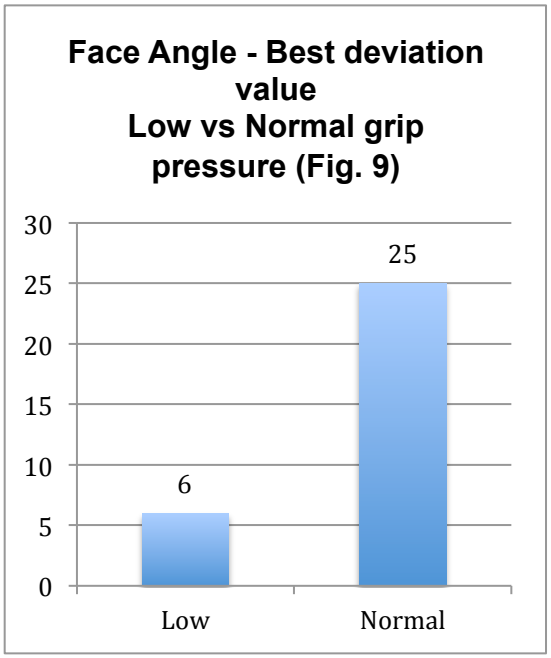
Comparing the values side by side its very noticeable. 68% of the players are performing their best club speed values when increasing their grip pressure above normal. With the lower pressure there are only two sessions producing better numbers and 26% of the sessions are creating best numbers with their normal pressure. (Fig. 8)



There seems not to be much doubt about it. Club speed is also being affected by grip pressure, but not in the way we thought. Only 6% of the 31 test sessions showed to increase the club speed with a lower grip pressure. While a number high as 68% would actually do it through applying more pressure. In other words the ball flight law of club head speed seems to be affected in the way that the more pressure applied the more club speed would be created.
Suggesting that players whom are struggling with creating club speed are more likely better of increasing the grip pressure rather than decreasing it.

5.4 Clubface position

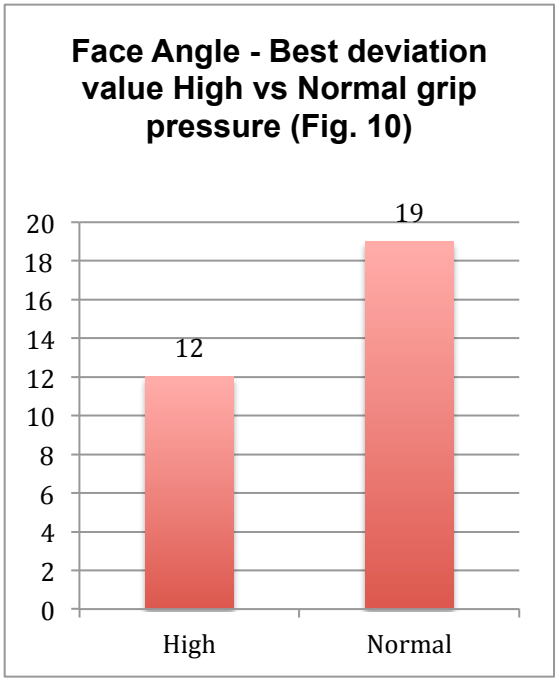
Face angle is another value that is a challenge to look into as it differs from player to player what they are trying to do. A positive value can be a dream for one and a nightmare for another. Therefore we decided that it is another value where deviation is of interest. Much like smash factor, for a player to be consistent knowing their ball flight is important, if the face sometimes is open and sometimes closed that is going to be rough. A consistent face angle at impact might produce an off target shot but if the player is consistent we can make them work with it.



5.4.1 Low grip pressure

In general players whom loosened their grip pressure seemed to wave goodbye to controlling the face angle.
Out of the 31 sessions revised only six of them actually became more consistent with their face angle through loosening their pressure. At the same time there is 26 sessions that produces a much more consistent face angle through not changing anything.

The sessions that are producing a good consistency with the lower grip pressure are showing to be players with a rather low club speed. Suggesting that players with lower speeds are having an easier time controlling the face angle even with the low grip pressure.

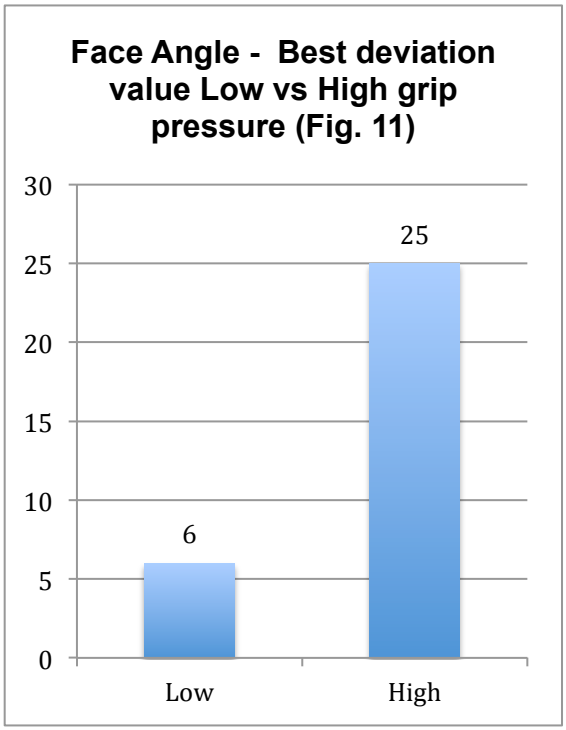


5.4.2 High grip pressure

Increasing the grip pressure for most players seem to produce control. A majority of the players are improving their deviation values with a normal or high grip pressure Most players getting a much more consistent ball flight and more often starting and curving the ball more similar than they would with their low grip pressure.

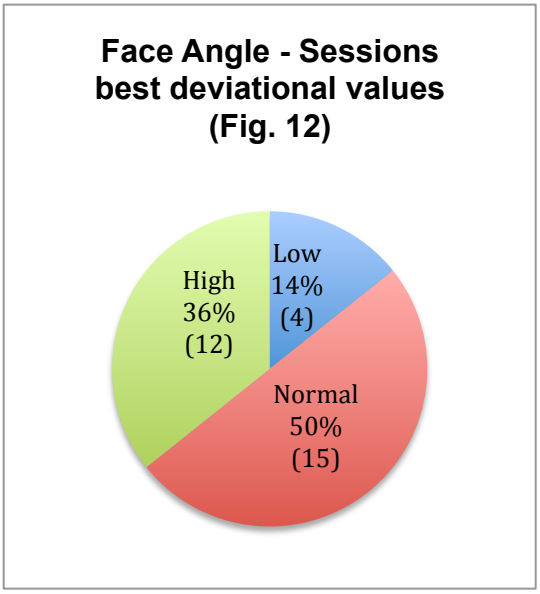
12 of the 31 sessions produced an improvement in their deviation value through applying higher grip pressure. 19 of the 31 sessions kept their values in better levels with normal grip pressure. (Fig. 10) The values are however very often very similar between the two grip pressures. Sometimes even the same deviation value was presented.

Comparing the low and high grip pressure for the face angle we get a majority of sessions being most consistent with the high grip pressure. 25 of the 31 sessions tested are showing improved results with the high grip pressure. Only six of the 31 sessions are producing better values through loosening the grip pressure. (Fig. 11)



Once again we can see a pattern through our comparisons. Only six sessions are producing better results with a lower grip pressure no matter if compared to the normal or high grip pressure. (Fig. 9&11) We can also see that the normal pressure is producing the better results in comparison to the high grip pressure as well. (Fig. 10) This would suggest that for players to be consistent with their face angle they need to keep the grip pressure from being lose with out tightening it too much.

As for the overview it too shows just what our more detailed summaries does. Half of the players tested were producing the most consistent shots using their normal grip pressure. 36% were increasing their values by increasing their grip pressure while only 14% of the 31 sessions were increasing theirs by lowering it. (Fig. 12)



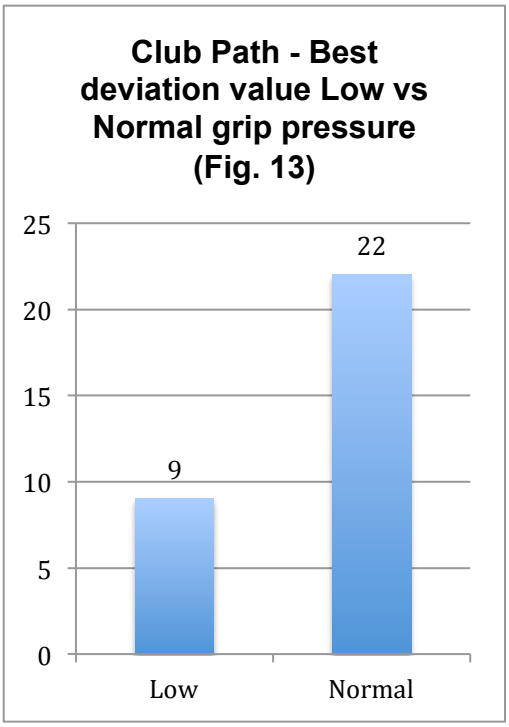
Clubface position is also being affected by grip pressure. With the low amount of sessions creating the best values with low grip pressure. Together with the comparisons between different grip pressures showing that a too low grip pressure will most likely make it harder for players to control or be consistent with their face angle. It also suggests that squeezing the club too much will also lower the chances of the same thing. But if you are after control you should be better off squeezing that golf club a little more rather than a little less.

5.5 Path of the club head

The club path is another value coming straight out of the radar without any calculations or other things like that. Once again the club path is much like face angle. The averages is changing a lot between players depending on varying variables but what we are looking for is to see consistency. So also for club path we are defining improvement or regression through the deviation value. In our world a consistent club path will create a consistent player.

5.5.1 Low grip pressure

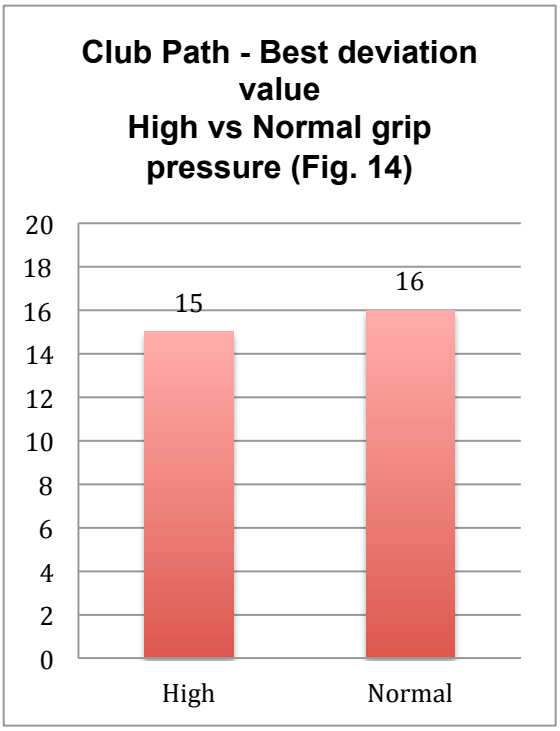
Club path seems to follow the face angle closely and the results are very similar. And just as for the face angle a low grip pressure seems to be preferable for a small amount of players while for most players it is creating less consistent golf shots. The amount of players being able to control the club path with the low pressure therefore seems quite limited.



Only nine out of the 31 sessions showed a better number in their lower grip pressure than with their normal one. 22 out of the 31 sessions produced a much more consistent club path value with their normal grip pressure. (Fig. 13) Much like the face angle the players whom seems to be more consistent with the lower grip pressure are players with lower club speeds. This makes it possible for them to keep control of the golf club through impact even if their grip is not as tight as normal.

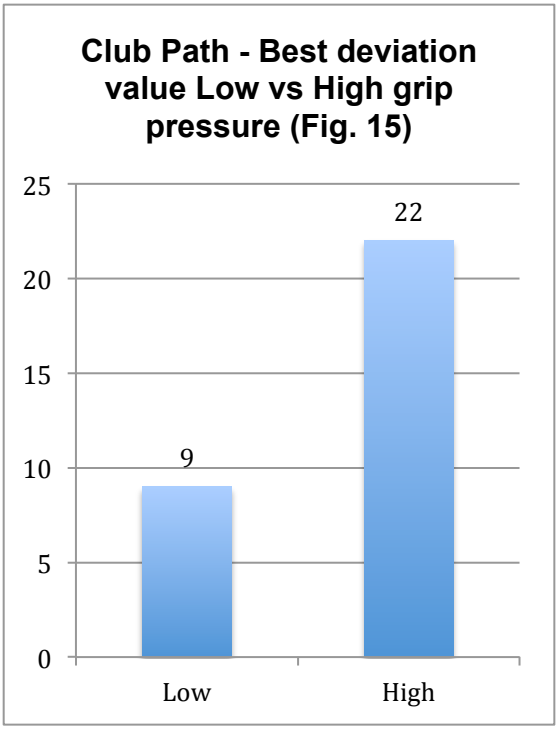
5.5.2 High grip pressure

First and foremost an increase in grip pressure seems to be an increase in control for the players, especially for the ones whom are creating a lot of speed in their club. Thus there is no real surprise that also club path is showing to be positively affected by a higher grip pressure.

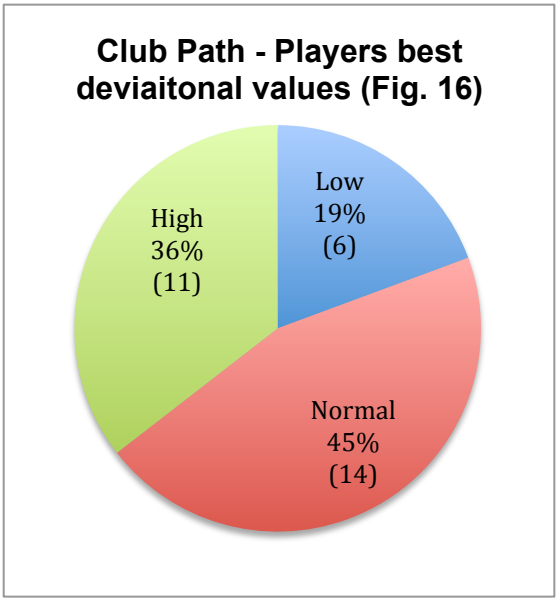


The 31 sessions resulted very equal. 15 of the 31 sessions showed the higher grip pressure being more consistent while 16 of the 31 session showed normal grip pressure being more consistent. (Fig. 14) Suggesting that either of the two are valid options for controlling the club through impact. Once again it seemed to be most players with higher club speeds whom gained control through gripping the club tighter. A few players using longer clubs also showed the same thing with the speed going up a tighter pressure would help to control the club.

Comparing the results between the lower and higher grip pressures we are seeing a similarity to the face angle once more. The amount of sessions producing the most consistent results with a low grip pressure are keeping steady at 9 out of 31 no matter what you compare them to. (Fig. 13&15)



Since the amount of sessions improving their club path consistency with a lower grip pressure stays the same in comparison with both normal and higher grip pressure. Suggesting that players whom are producing the most consistent club path with their normal grip pressure ought to be better off increasing their grip pressure rather than decreasing it.



If we compare the best values of the sessions in all three grip pressures the normal grip pressure seems to keep being the most efficient way for most players. Close to half of all the players are most consistent with their club path while keeping their normal grip pressure. 36% are being more consistent if they squeeze the club that bit harder whilst 19% of the sessions are easing up on the grip pressure but getting more consistent. (Fig.16)

Club head path is also proving to be affected by the grip pressure of the player. 81% of the sessions performed better with a grip pressure that was more tight, either their normal one or above that. The tighter grip pressure is definitely making the players more consistent with their club paths over all. Our comparison also shows that the majority of the players would be better off increasing their grip pressure to become more consistent. (Fig. 13&15) So much like clubface position you would be better off squeezing that club a little bit extra than not enough.

5.6 Angle of approach

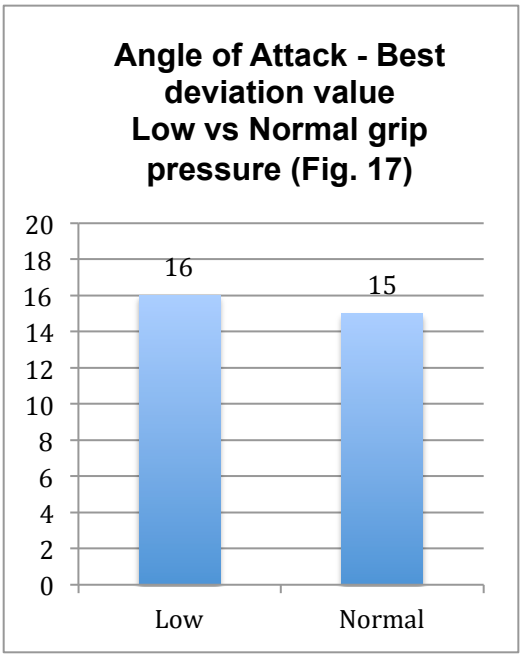
The angle of attack FlightScope-value is covering angle of approach, as we have mentioned the angle of attack is what is seen as the problem area for the FlightScope. As the value supposedly has a rather large variation in comparison with other radars also this value we will not claim to be fact but a good hint of which way it goes. We are basing both the average value and the deviation from a good amount of shots and as such we consider it to be very close to accurate.

Angle of approach is just like face angle or club path. It depends. Comparing averages would not really get us anywhere so we will be looking at the deviation value between different shots. Also the value derived from the attack angle is very different depending on which club that is being hit. The average value for it is not really proving anything but simply is helping us see how consistent the FlightScope is to provide us with numbers.

5.6.1 Low grip pressure

The lower grip pressure seems to be a rather good way for some players to become more consistent. In fact 16 of the sessions we tested were more consistent with their attack angle even with the lower grip pressure. Our research is suggesting that more experienced players with shorter irons are especially getting more consistent with their angle of approach when gripping the club more loosely.

16 out of the 31 sessions recorded were showing an improvement in consistency with their angle of attack when they decreased their grip pressure. 15 out of the 31 kept producing the most consistent numbers through keeping their normal pressure. (Fig. 17)

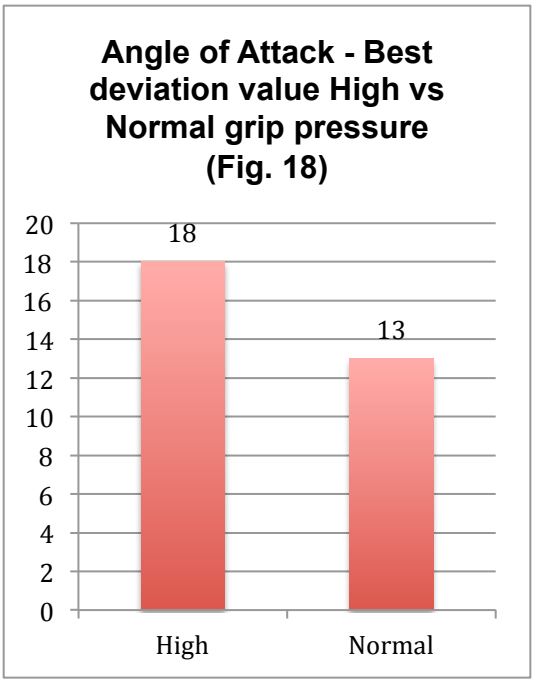


The players whom seem to benefit the most from the grip pressure change to become more consistent with the angle of attack are in general the more experienced, better players. These players seemed to be able to produce a higher consistency while loosening the grip pressure with both their low and mid irons.

5.6.2 High grip pressure

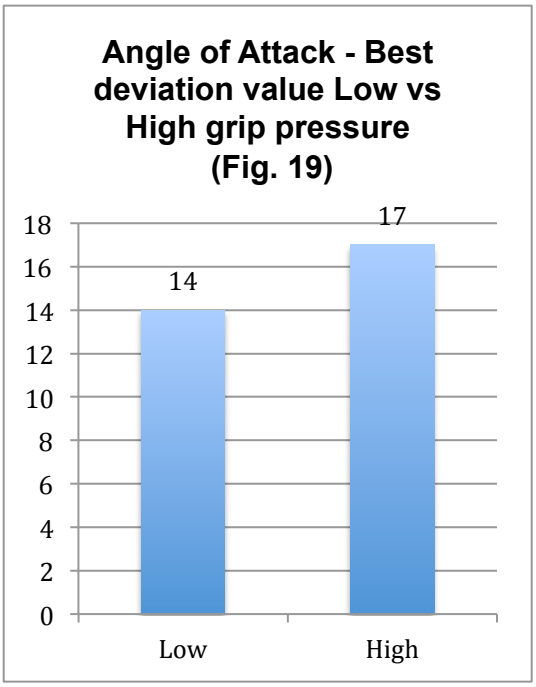
Once more an increase in grip pressure is producing what seems to us very steady and consistent numbers. The deviation value seems not only smaller in a majority of the cases but overall the consistency seems to keep very steady. Creating what seems like some kind of trend emerging that despite what club, most players are in general very consistent when they are applying a higher grip pressure.

The numbers are showing that 18 of 31 sessions are showing an improvement in the angle of attack when the grip pressure increases. 13 out of the 31 sessions are also showing to be more consistent when kept at the normal grip pressure level. (Fig. 18)

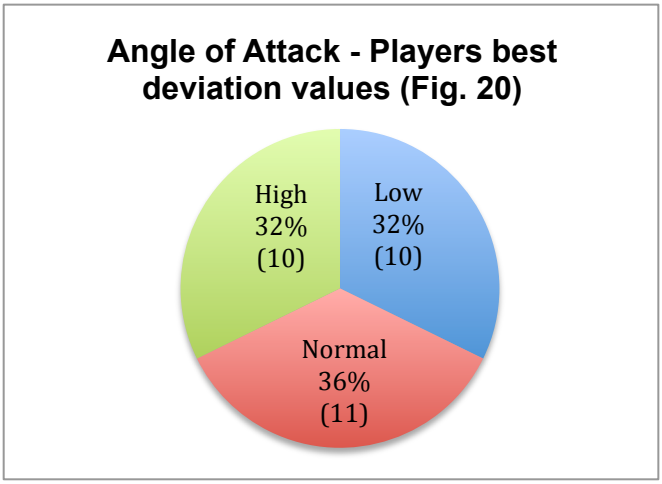


Comparing the low and high grip pressure to one another it is very similar. 17 out of the 31 sessions showed an improvement for the players gripping with higher pressure rather than lower. 14 out of the 31 would show the opposite. (Fig. 19)

Looking over the numbers there seems to be a very similar model between all three grip pressures. A small majority of the sessions showed a better performance with low grip pressure in comparison to the normal. (Fig. 17) At the same time higher grip pressure seem to be producing more solid, consistent numbers in the angle of attack than both the low and normal grip pressure. (Fig. 18 & 19) Possibly correlating with the different patterns we are seeing. Where more experienced players are producing the best angle of approach values with their mid and low irons using a lower than normal grip pressure. And less experienced players are able to produce more solid numbers all round by applying more grip pressure.



The overall view of the values produced mirrors the other findings as well. Pretty much a third of every session produces the most consistent angle of attack values with different grip pressures. While the high and low grip pressure have an equal number of sessions that performed best, ten each. Normal grip pressure is producing the larger amounts of good numbers by a margin at 36%. (Fig. 20)



The even numbers we see as a possibility to that grip pressure is affecting the angle of approach, however it is very unique for every club and player. As we are seeing a few trends, for instance that a lot of the more experience players are more consistent with their lower irons if their grip pressure is lower than normal. It is possible that it depends on so many other parts of the golfer that it is hard to determine.

There is also the possibility of the FlightScope being inconsistent and providing us with some data that might not be accurate. As tests show that the FlightScope can produce inconsistent numbers that can throw off both our deviation and average value. We however see that as most unlikely since we have removed the highest and lowest values for our calculations but also see no real throw offs in our data over all. If the FlightScope is delivering false numbers its doing it very consistently on our tests.

So yes, also this ball flight law is affected by grip pressure. It seems to be the ball flight law that shows most adversity and dependency of club, club speed and of course player. We would say that with the results we are seeing on angle of approach with difference grip pressure it depends on many variables which grip pressure is the best for each player to be more consistent with the angle of approach. But if a player is struggling with being consistent in the angle of approach a change in grip pressure could help them out.

6.0 Conclusion of the work

The best way to conclude our work would be to admit that we feel sorry for Mr. Sneads little baby bird. That bird is going to have it rough from now on. We will be the first ones to admit, we have been teaching and we have been preaching for a good while – make sure you do not grip the club to tight!

But what we are seeing here, what our work actually comes to show, is that it is wrong. Losing up your grip pressure is not going to help you hit the ball further, it is most likely not going to help you be more accurate and it is most likely not going to help you play better golf. Our research shows that of the 31 sessions we tested, 74% of them had a more consistent ball striking with normal or above normal grip pressure. 94% of them had a higher club speed with normal or above normal grip pressure. Club path and face angle both had a higher consistency in more than 80% (86 and 82) of the tests with normal or above normal grip pressure. The only one that was really close would be angle of approach where just 66% had a more consistent result with a normal or above normal grip pressure.

This shows us that a looser grip pressure should not be something to strive for it should rather be avoided. Perhaps a player should not either grip the club as hard as humanly possible, but it does show us that if you were to chose increasing your grip pressure is by far the best option.

Let us run an example by you. You get a lesson, a 58-year-old man who has been playing golf for 30 years. He comes to you cause he have problems with his golf, he is not hitting the ball far enough and it has a tendency to slice like crazy. There are probably hundreds of ways to attack the problems this guy is having, you are probably thinking about them right now. But have the option to increase his grip pressure ever come to mind? If you could tell your student to increase the grip pressure and he would gain both distance and become more consistent with his slice. Would that student come back to you? Would he find it easier to adjust than changing several other things in the swing?

We have tried increasing the pressure ourselves when hitting golf balls. And to no big surprise it feels really odd during the first shots, the split seconds before your take off you could even wonder what you are hoping to accomplish. But to be honest, is no that exactly what every player feels when we are implanting a setup change or a change to the swing? We are not declaring it to be some kind of magic quick fix that will work right out the box. But it is likely to be one of the easiest changes for players to comprehend and to execute well. Thus making it a very valid option.

Our result can help change the way we are looking at grip pressure in our teaching today. Making it a good tool for both teachers and players to help with different problems they are having at the course. Through further our understanding of grip pressure, how it affects both the player but especially the ball flight laws we think it is possible to start doing just that.

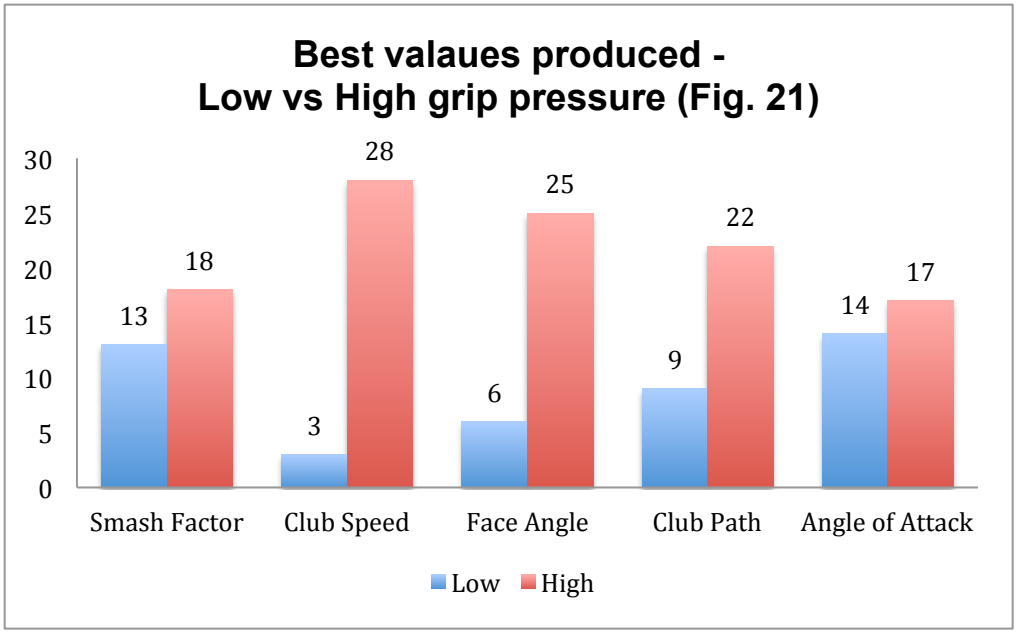
7.0 Summary

Up until now the general state of mind regarding grip pressure in our golf swing is one and the same. A lighter grip pressure is preferred, it will make you not only more accurate but also create more speed and with it distance. From the start of your golf career you are being bombed with arguments that you are gripping the club too tight and that it is destroying your chances of producing a good and solid golf swing.

But we are unable to find any facts backing it up and figured that it would be a great idea for our work. Simply figuring out whether or not grip pressure actually had the influence on the ball flight laws that the way we are preaching it is suggested. And if it had an influence, would it actually show us once and for all that lower grip pressure is the way to go?

We set out on a mission to find out, we recorded the grip pressure and ball flight of close to 1000 golf shots. The data we were able to compile would help us answer our question. But to our surprise it showed a very different result than we expected. Sure, the grip pressure is directly affecting our ball flight laws. What we however never thought would happen is that our research showed the surprising result; if you want to have control and gain more speed, apply more grip pressure.

Going over the results of our test in detail out of the perspective of every one of the five ball flight laws we can only conclude that a majority of players would benefit from gripping the club more tightly (Fig. 21). Our studies are showing that players increasing their grip pressure are becoming more consistent in their ball striking and increase their swing speed. Every ball flight law except angle of approach is showing improvement when the grip pressure is increasing, and the angle of approach is matching that off the normal pressure. Our research also shows that a high grip pressure is without a doubt a better choice over the lower grip pressure.



Our result is possible to change the way we look at grip pressure in todays teaching of golf. It is possible to help us to better understand the principles of grip pressure in the golf swing and how it affects the golf swing. We sat out to find out whether or not grip pressure would actually affect the ball flight laws and found something very interesting. To conclude our work it is to us very obvious that if you wish to improve consistency or swing speed, applying more grip pressure is the way to go and loosening the pressure is not.

Now our result just left us with one thing more to figure out, why? Why have we always been talking about the light grip pressure? Why have high grip pressure always been considered the "swing-killer"? Wrapping our heads around the biomechanics of the golf swing through the whole body was never really considered. But we would actually guess that is where the answer is and as Mr. Nicklaus puts it *"And I'd guess that this is probably true of most "legs and body" players as opposed to "hands and arms" golfers".*

Most of our "gripping muscles" are located in our lower arms. (Jason Shea, 2011) If we squeeze that club as hard as we possibly can, of course our lower arms are going to feel stiff. But what about the rest of the body, is it really as stiff as we would think? It would seem not. And to make it even more interesting, what body parts are most golfers using to create a golf swing. Well, some would probably use their lower arms, but far from everyone and to be fair the "lower arm golfers" are probably a minority.

Now if we think about the lose grip pressure again, our theory is starting to take shape. Say you pick up a golf club to get the feel for it, what do you do? Commonly known as the waggle you try to imitate your release to get a feel for the club. You know you are just going to do a small motion in your lower arms, so you do not need an excessive amount of force in your grip. So the waggle feels smooth and nice for your body. But try doing the waggle while holding the club as tight as you possibly can. It is so close to impossible it is scary, and you will never be buying that club cause it feels awful. Often the release is referred to in the same mention as the low grip pressure and it probably would not be to farfetched to guess that it had been tested in waggle kind of way. And that would quite naturally explain why you would get the feeling that it is close to impossible to release the club with a high grip pressure.

But with increasing the grip pressure in a full power shot and not just a waggle seems to be able to produce powerful and accurate shots. The release seems to be present even then; most likely due to the speed and the strength your gripping muscles would need to stop the power converging from the legs up. Nicklaus is probably right in his comment about the need for golfers to have a body swing in order for it to work properly. But what we cannot really understand is why no one has tried it before.

7.1 Other shots?

We have solely been focusing on the full shots of the golf swing for our research, as we do think that is where the biggest changes are possible to occur. For other shots, such as the short game we do not really have any clue nor have we done any testing for it. We do however consider the short game and the full swing to be two different things and that just because something works for one part it does not make it a good match for the other.

Possibly there are some short game shots that will benefit from a higher grip pressure. Just as it is possible for the exact opposite to happen. If we were to bet on something a somewhat looser grip pressure would be the more beneficial way to grip the club when in close proximity to the greens.

We do however consider it to be quite an interesting idea to at least try out. We are all pretty sure that a softer grip pressure is to be preferred on the short game shots but so we also thought about the full shots before we started our work. Hence we do have an open mind about it. Considering that you would move in much more detailed and smaller motions, it would seem rather strange if that was not the case however.

7.2 Difference between players?

Comparing players would seem a pretty obvious thing to do, getting a grip of how players of different level adapted to grip pressure changes. We however do not consider the gender aspect to be important, as we would consider it more interesting to base it of players handicap, club speed or age.

Now the biggest difference we could see can be lead back to the players experience. Player whom have played a lot more, got lots of time on the range and whom have more experience in general all seemed to be able to adapt much more easily to the different grip pressure changes. Most likely due to the fact that if you hit enough golf balls, practice and want to improve you are going to try things out and grip pressure is probably one of them.

We could also see what we would like to call trends. For instance a lot of players whom gripped the club more tightly were able to keep somewhat steady numbers despite the use of different clubs. Whilst if the same player would loosen up their pressure the different clubs would produce very varying numbers. That trend was quite obvious through most players, despite level of playing experience.

7.3 Suggestions for future research

We do believe that our result opens up for a good majority of possible ways to future research our findings and further increase the knowledge of the subject. The first one that would most likely help the credibility of the research in the eyes of many are reproducing the same test with a TrackMan recording the ball flight of the golf balls. Seeing possible changes in especially angle of attack.

Further we would suggest going more in depth when it comes to differences between players of different levels, their grip pressure and their affect on ball flight laws. We do have an idea about it and are able to say a lot by our data, however a more in depth look at it would most likely help either confirm or deny our ideas. We do believe that it would be a key to even further integrate grip pressure in teaching golf. Finding a perfect grip pressure would probably be impossible but recognizing trends for different kind of players should not be to hard.

We would also find it interesting to further research of grip pressure into more detailed segments of the swing. Much like the works of E R Komi, J R Roberts and S J Rothberg but possible correlating the detailed segments with different ball flights.

Last but not least trying out using grip pressure as an active part in giving golf lessons to players of different levels. And in general using it as an active part of the philosophy to review whether or not it is as useful as we are believing it to be.

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9.0 Enclosures

Enclosure A – Summary – Grip pressure
Enclosure B – Final compilation H-L Values removed
Enclosure C – Final full compilation
Enclosure D – Participants