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Interaction between gloves and ball surfaces in AFL and Rugby

Internship Report

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Preface

This report was made during my internship period at the Royal Melbourne Institute of Technology from June till September 2012 at the School of Aerospace, Mechanical and Manufacturing Engineering as a part of the curriculum for my MSc degree in Mechanical Engineering. The internship was done inside the Sports Engineering section of RMIT.
It took some time to get everything arranged, but on June 10th I finally departed for a four month period of internship and traveling and I think this is the right place to say I had a great time in Melbourne.
I want to thank all the people involved in creating the opportunity to go abroad for this internship and especially Prof. Franz 'Tino' Fuss and Patrick Clifton for their supervision and help during the project. A second thank you has to go to Natalie Robson and Francois Richard for their company during the whole period, without you it would have been a lot more boring than it was now.
Of course also my girlfriend Esmée, my parents and the rest of my family deserve a thank you, because they supported me through the whole process of arranging everything and actually departing for a period of four months.

Summary

In Australian Football players are allowed to wear gloves to keep their hand safe. The gloves used are of different types and they are made as sticky as possible, resulting in these players having an advantage over other players when catching a ball. The AFL now wants to know how much the players benefit and this has resulted in this research in quantifying the advantage when wearing these gloves. Ten different types of gloves have been tested on four different surfaces. Some of the gloves tested have an all silicon palm of the hand, while others are made out of leather or have a thin silicon pattern on a spandex palm. The tests were done by pulling a glove over a surface mounted on a forceplate. This forceplate measures normal and frictional force during the measurement and from that data the coefficient of friction can be calculated as the fraction of both. To compare the results and to broaden the research, five of the gloves were also tested on ten different rugby surfaces ranging from smooth panels to different pimple patterns. Because the gloves show signs of wear quickly, it was decided to also test them in old and new conditions. All these tests lead to the most important conclusion that for AFL a few gloves make a significant difference in performance, all being gloves with a majority of silicone in the palm. It is however highly dependent on the hand that is tested, because there were two different hands tested and they both show different behavior. This can of course be explained by the uniqueness of every hand. Gloves are not of significant use when one wants to perform better in rugby, because both hands tested already have a high coefficient of friction. Another important conclusion to be drawn is that the silicon gloves are performing better in dry conditions and the leather gloves slightly better in the wet.

Contents

Chapter 1

Introduction

1.1 Research Aim

The aim of this research was to investigate the friction of different glove against different AFL and rugby ball surfaces. This was done with old and new gloves and in dry and wet conditions. A quantitative result of the coefficient of friction was aimed for to conclude anything about the behavior of both the gloves and the surfaces.

1.2 Sports Background

Rugby is commonly known throughout the world and is played in a few different ways of which the best known are League and Union Football. League Football is a bit faster and therefore it is also more interesting to watch for the general crowd.
Australian Football (AFL) is a sport played on a professional basis only in Australia during the winter from April till September. The pace of the game is quite high and the roughness is like rugby. The pitch is oval and the long axis is about 170 meters long, see Figure 1.1. Like with rugby, a score can be made by kicking the ball between two poles, which gives the team six points. Also one instead of six points can be scored if the ball goes between one of the high poles and a lower pole next to it. One of the most important characteristics of AFL is marking the ball, which is catching the ball out of a kick, see Figure 1.2 and Figure 1.3. The official definition according to the rules of the AFL[1] is:

> A Mark is taken if, in the opinion of the field umpire, a player catches or takes control of the football:
>
> (a) within the playing surface; and
> (b) after it has been kicked by another player a distance of at least 15 meters; and
> (c) which has not touched the ground or been touched by another player during the period when the football was kicked until it was caught or controlled by the player.

After the ball has been marked, the player is entitled to take some space to pass the ball to another player or to try and kick the ball between the poles.

1.3 Research Background

Marking is usually done with two hands and subsequently the ball is brought to the chest to make sure the player holds it. Players often use gloves when they are injured, to make sure the hand is safer. It is observed that players that wear these gloves have great benefits of wearing them, because the surface roughness of the glove is higher than the surface roughness of the hand. This means that the players can more easily mark the ball when wearing a glove, because they have more grip. Players also tend to keep wearing the gloves, because they feel they have an advantage over using the normal hand.
For rugby the general handling of a ball is very important and this means that if gloves make handling more easy, the players would possibly start wearing them.
The Australian Football League wants to know how much the players benefit and maybe want to regulate the type of gloves to be used by the players. The aim of the research is to analyze the benefits of the

Figure 1.1: The oval shape of an AFL pitch

Figure 1.2: An official Australian Football

Figure 1.3: A mark taken

gloves and to obtain a quantitative result for the different types of gloves that are used in AFL at the moment. This will be done by doing friction tests of the gloves on the leather of the AFL ball and different rugby surfaces.

1.4 Research

There are a few main objectives for the research. The first and most important is to test 10 different gloves in a new condition on all four AFL surfaces. Five of these gloves will also be tested in old conditions and on all ten rugby surfaces. A further objective is to analyse the data to obtain a quantitative result for all the gloves against all surfaces tested. Once this has been done, one can draw conclusions about the behavior of the different gloves in the dry and the wet and in old and new conditions. These test results will be compared to test results from bare hands from two different persons.
As a further research objective, the test setup has to be standardized to make the measurements more constant and the forces that appear in normal conditions when marking a ball have to be known to limit the force and velocity region in which the experiments have to be done.

Chapter 2

Previous Research and Theory

2.1 Theory

2.1.1 Friction

When sliding a glove over a surface, the coefficient of friction is defined as the ratio between friction force F and normal force N:

$$\mu = \frac{F}{N} \tag{2.1}$$

The coefficient of friction can also be brought back to a main simple example of a block on a sloped surface. The point where the block starts to slide is the point where the regime transitions from static to kinetic friction. The higher the coefficient of friction becomes, the bigger the angle at which the block starts to slide. For low coefficients of friction, a difference of a tenth in the COF results in a difference in the sliding angle of 3 to 5°, but when the COF becomes higher than 2, the difference of a tenth in the COF results in a 1° difference, and this decreases even further with higher values for the COF. This means that for higher values of the coefficient of friction, bigger differences between values are less significant.

2.1.2 Force Measurements

Before the field measurements were actually done, an estimate of the force was made. For this, the parameters in the flight stage have to be known or estimated with a certain degree of certainty. Ball [6] researched accuracy of kicks in AFL and for this he measured the starting velocity of the ball for 30 and 50 meter kicks. To use the extremes, the 50 meter kick was taken as a reference. The starting velocity of the ball for these kicks was 25 ms^{-1}, so this was taken as the velocity at the start of the kick. To calculate the velocity of the ball at the marking point, the drag force has to be taken into account. The drag force is given as:

$$F_d = \frac{1}{2}\rho A c_d v^2 \tag{2.2}$$

Here, ρ is the density of air, which is about 1.225 kgm^{-3}, A is the surface area of the ball, which is varying through time, so an average of 0.033 m^2 is taken as value to work with, this is between the minimum and maximum value of the surface. v is the velocity and c_d is the aerodynamic drag coefficient, which is taken as 0.1. Drag force is then computed as $1.263N$. To know the end velocity, the drag in x-direction was computed with an average attack angle of 22.5 degrees, leading to a value of $1.167N$. The deceleration in x-direction is subsequently calculated, with the mass of the official ball being 450 g and with that value also the end velocity in x-direction and the end velocity, taking into account that a kick has about three seconds of airtime:

$$\Delta a_x = \frac{F}{m} = \frac{1.167}{0.45} = 2.59\ ms^{-2} \tag{2.3}$$

$$v_{x(end)} = 17.677 - 3 * 2.59 = 9.91\ ms^{-1} \tag{2.4}$$

$$v_{end} = \frac{10}{\cos(45^{\circ})} = 14.14\ ms^{-1} \tag{2.5}$$

With this value and the mass, the total momentum can be calculated and subsequently the force, taking into account that the time to catch the ball is taken as about 0.5 s:

$$p_{end} = m \cdot v_{end} = 0.45 \cdot 14.14 = 6.36Ns \quad (2.6)$$

$$F = \frac{\Delta p}{\Delta t} = \frac{6.36}{0.5} = 12.7N \quad (2.7)$$

Because the player is catching the ball with two hands normally, this becomes 6.36 N per hand. There are however some parameters that can change, like the time a mark takes and the actual drag force. Because the velocity of the ball decreases during flight, also the drag force decreases and does so with the square of the velocity. The actual deceleration of the ball will thus be lower and the end velocity will be higher, resulting in a higher force. If an average drag force of 0.95 is taken for the whole flight, the end velocity would become 16.55 ms^{-1} and the force would end up at 7.45 N per hand, which is about 1.5 times the weight of the ball per hand. What also has to be noted in this case is the direction of the ball compared to the hands that are catching it. The hands come from the side, so they exert a normal force at the ball and the ball is to be slowed down in the tangential direction of that. This means that the force actually acting on the hands will be higher than the force calculated above. Next to that also the fact that players use more force than ideally needed to catch the ball has to be taken into account, so the force will be even higher.

2.2 Previous Research

For AFL surfaces, there was no real research found on friction between ball and glove surfaces, but for rugby there was some more previous research. The first research into friction between hand and ball in rugby was done by Tomlinson et al[2], comparing performance with three different gloves and the bare hand. The method they used was different than the method used in this project and they also said that there were a lot of factors that contributed to uncertainties in the results of the experiments. For example, they only did one test per condition and only used one rugby surface. In 2009, Tomlinson et al [3] did research on the friction between rugby balls and the skin of the hand and tried to visualize the handling of the ball. They did tests with four different pimple patterns of the ball and researched difference between dry and wet surfaces. Tomlinson et al [4] also did research into friction between human finger and flat contacting surfaces. They researched differences in different moisture conditions and evaluated some of the hypotheses posted before. They concluded it was very difficult to draw quantitative conclusions from the study, because there are a lot of external factors in the research method, like ambient conditions and difference between test subjects. A qualitative conclusion was drawn however that finger friction increases when someone is active, because of the sweat on the hand. In 2012, Fuss [5] did research into the behavior of the coefficient of friction of rugby ball surfaces. He concluded that if velocity or normal force is increasing, the coefficient of friction will first start to increase (strengthening part) and will subsequently decrease again (weakening region). The reason for this is that if the velocity for example becomes high enough, there will be a stick-slip effect. This effect makes that the two surfaces sliding over each other will just slip away and therefore the friction will become lower. The point where slip starts to occur is the point of impending slippage. At this point the friction coefficient has the highest value. The strenghtening and weakening parts of the regimes form a master surface in 3D, with velocity and force in $\log_{10}$ scales on the horizontal x- and y-axes and coefficient of friction on the vertical z-axis [5]. The master surface indicates that the coefficient of friction between the ball and the hand in AFL and rugby also depends highly on the velocity with which they slide over each other and the force with which the ball is caught by the player.

Chapter 3

Method

For the first part of the research, the different AFL and rugby ball surfaces were clamped to a Kistler Force Plate of the type 9260AA (Kistler, Winterthur, Switzerland) with a clamping bar on one side (see Figure 3.1) and a weight of 5 kg at the other side of the plate. Signal acquisition was done by a Kistler DAQ system for Bioware, type 5691. A measurement consisted of putting the glove on the surface with a total weight of 2.5 kg on it and subsequently pulling it over the force plate with constant velocity. This is shown in Figure 3.2 and Figure 3.3, the arrows indicate the direction the glove was pulled. For hand measurements, the same method was used, except for the normal force, which is exerted by the hand instead of weight. A measurement took 30 seconds in total and in that time, the glove and weights had to be put on the surface and the glove was pulled over the surface. Before every measurement, the plate forces were calibrated to make sure that the force output was only from the glove with weight on it. To get the glove sliding over the surface, first the static friction coefficient had to be reached. If this is the case, the glove starts sliding and the coefficient of friction drops again slightly. Once the glove was sliding, the velocity was kept as constant as possible, to allow for a good measurement. Sampling of the forces was done at 1 kHz.
Analyzing the raw data was done with Grapher. The coefficient of friction was calculated from a time period in which the shear force is constant. This time period was usually taken as a period of 5 seconds, after which the coefficient of friction is averaged over that period. Six measurements were done for every glove on every surface, after which the average of these five values was calculated as the mean friction coefficient between the two surfaces. During one set of testing, meaning all gloves dry or wet on one surface, 6 tests were done per glove in sets of 3. After each third test, another glove was used to make sure that the tests were repeatable. The wet tests were done with an amount of water on the surface, that covers the whole of the sliding path. This was done to ensure approximately the same conditions during all tests. The surfaces are hydrophobic, so they were not treated with water beforehand, because this does not make a difference. The Gripworx glove and the two Nike's are also hydrophobic, but the Franklin glove is hydrophilic and therefore it had to be soaked, because behavior will be different with different amounts of water, as the material can absorb the water. If the glove is soaked, it is not able to absorb any more water, so the behavior will be the same for all measurements. After a series of measurements on a surface, the glove was submerged again in water to keep it soaked.

3.1 Gloves

Ten different gloves were used for the testing, all on the AFL surfaces and five on the rugby surfaces. The best distinction between the gloves was that there were two leather ones, two gloves with a thin silicon pattern on the palm, one with silicon pimples, one with silicon patches and four all silicon palm gloves. In Table 3.1 an overview is given of the gloves with palm material and the compositions of those materials when known. The gloves in italics were tested on both the rugby surfaces and the AFL surfaces. To make sure the measurements were the same, the fingers are cut off from the gloves to leave only the palm area to make contact with the surface. The Gripworx complete glove and the tested Magnigrip glove are shown in Figure 3.5 and Figure 3.6. The rest of the gloves can be found in Appendix A, including pictures of the whole gloves and details of new and worn gloves.

Figure 3.1: The force plate used in the experiments

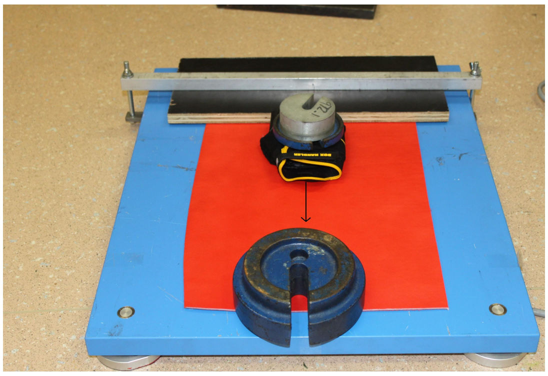

Figure 3.2: The test setup in total

Figure 3.3: Detail of the glove with weight put onto it

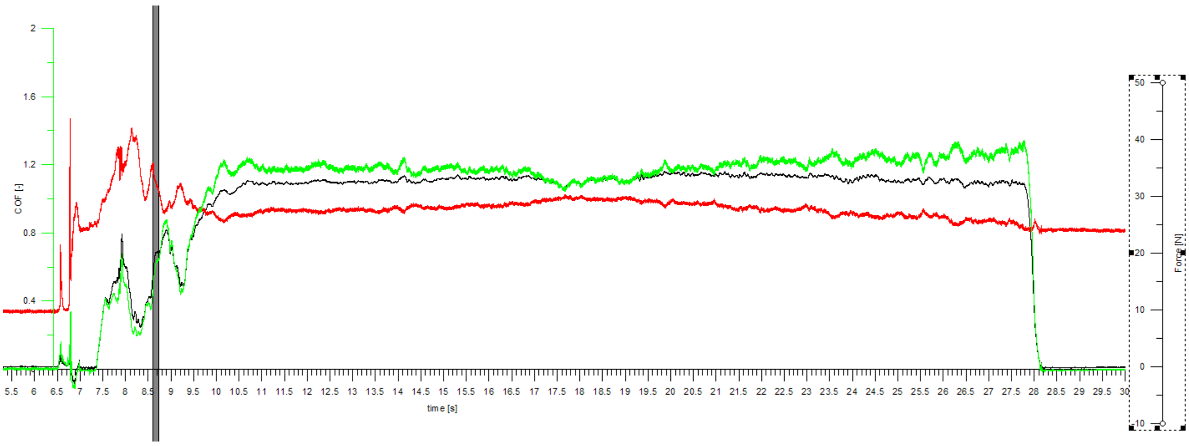

Figure 3.4: Raw measurement data from an experiment

Figure 3.5: Complete Gripworx glove

Figure 3.6: Nike Magnigrip glove

Glove	**Palm material**	**Material composition remarks**
Franklin	Synthetic Leather	digitally impregnated leather
Gilbert Netball	Flat silicon pattern	polyester pattern on lycra
Gilbert Rugby	Rectangular silicon pimple pattern	-
Grays Skinfit Hockey	flat silicon pattern	-
Gripworx Ironclad	Silicon patches	60% nylon, 40% polyurethane
Nike Superbad	All silicon palm	glove: 62% polyester, 18% nylon, 12% silicone, 8% neoprene
Nike Magnigrip Elite 2.0	All silicon palm	-
Nike Vaporjet	All silicon palm	50% silicone, 40%polyester, 7%neoprene, 3% nylon
Rawlings	Leather	-
Under Armour Blur II	All silicon palm	50% polyester, 50% Polyvinyl Chloride

Table 3.1: Overview of gloves and palm materials

3.2 Surfaces

Two different official AFL surfaces were used to test the gloves on. These surfaces were both imprinted with a logo of a sponsor. Next to these two surfaces, two patches of the original leather without any prints were used, because one can feel the difference between the normal leather and the print on it. One of these patches was of the red leather used and the other one was the yellow leather. The rugby surfaces are made of rubber, which makes the behavior different, especially in combination with the different gloves. Three of the different rugby surfaces are also currently used in different rugby leagues, like the Rugby Union (UCO), Rugby League(NRL) and the Japanese Rugby League(FIJ). Two other surfaces were smooth, but with a difference in the composition of the material (SMO A and SMO B), one surface was an experimental surface with ordered pimples in perpendicular lines (REG) and the last surface had a snowflake pimple pattern (SNO) and this one is also experimental. The last two surfaces, as well as the NRL surface had a direction dependent pattern, which means that the coefficient of friction could be different in different directions. This means that they had to be tested in two directions, so the perpendicular pattern was tested in 0° and in 45° direction and the snowflake and Japanese pattern in two directions perpendicular to each other. This makes a total of 14 surfaces tested in both dry and wet conditions. All rugby surfaces used are summarized in Table 3.2. The Yellow official AFL ball patch is shown in Figure 3.7 and a detail of the UCO rugby surface in Figure 3.8. The rest of the surfaces are given in Appendix B, with details of all the pimple patterns.

3.3 Force Measurements

For the actual force measurements, a glove and a ball were instrumented with sensors to measure the forces during some normal actions like passing, kicking and marking the ball. With the sensors in the ball, it is possible to look at the kinematics of the ball during flight, so one can see for example how much spin is on the ball and also the forces acting on the ball during release, flight and catch can be measured. The instrumented ball can be seen in Figure 3.9, all laces were cut afterwards to test the ball. The hand was instrumented inside the glove. A total of eight sensors were put on the glove to measure

Surface	Pimple Pattern	Remarks
SMO A	No pimples	Rugby ball material without pattern
SMO B	No pimples	New composition
REG	Ordered rectangular	Experimental
UCO	Not ordered	Used in Rugby Union
NRL	Not Ordered	Used in Rugby League
FIJ	Not ordered	Used in Japanese League
SNO	Snowflake pattern	Experimental

Table 3.2: Different pimple patterns of the surfaces and where they are used

Figure 3.7: Yellow AFL ball patch used for testing

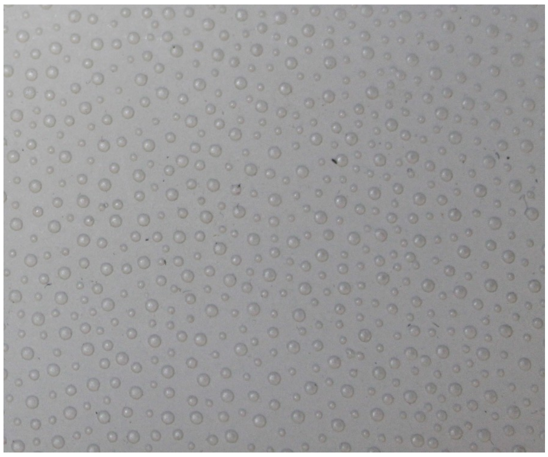

Figure 3.8: Detail of the UCO pattern

the division of the forces. Five of these were put on the inside top of the fingers and three on the palm of the hand. The instrumentation for the hand is shown in Figure 3.10. The eight sensors can be seen on the left side and they are connected to a recording device, which can be connected to a computer via USB, so one can read the data.

Figure 3.9: The instrumented ball

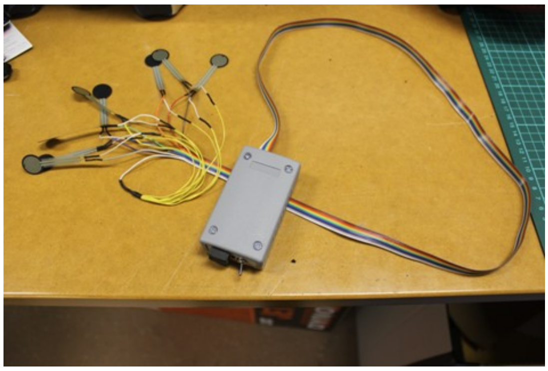

Figure 3.10: The instrumentation used for measuring the force on the hand

Chapter 4

Results and Analysis

All measurements were done by hand (male, 24 y/o) and because of this, it was impossible to do all measurements with exactly the same circumstances. For comparison, the hand testing was done by two different male persons of 24 and 49 years old respectively. The measurements which were clearly outliers were discarded directly. Per glove-surface combination 6 measurements were done of which most of the times one was evidently not following the trend of the other measurements. This was also discarded to leave five measurements for each glove on each surface. The average of these five values is taken as the coefficient of friction. One important thing to note is the fact that the gloves show signs of wear quickly during the measurements, so the gloves are only used as new gloves for the first 15 to 30 measurements, depending on the amount of wear showing on the glove. Because a difference is noted between old and new gloves, the measurements done are also distinguishing between new and worn gloves and after measuring three or four surfaces, a new glove has to be used. However, the difference between worn and new gloves is not the same for every surface, so it is not possible to say that old or new gloves are better by definition. The wear on the Gripworx glove can be seen in Figure 4.1. The wear shows at the patches that are more dull at for example the bottom center, compared to the patches at the right. The place the patches wear off corresponds to the place where the weight is put on it, because it is a circular shaped weight with a hole in the middle. This in its turn also corresponds to the parts of the hand that make the most contact with a ball when catching it, because the center of the palm is a bit deeper than the edges. The results are separated into a section for the results on AFL surfaces and a section for the rugby surfaces, because there are more gloves tested on the plain leather AFL surfaces. A seperate section is dedicated to the individual gloves to show the behavior if they behave better in the dry or in the wet, also with a comparison with the hand. All coefficients of friction can be found in Appendix C, Table C.1 for AFL, Table C.2 for rugby and Table C.3 for the bare hand testing.
A setback for the results section is that new pairs of the Nike Magnigrip and Vaporjet gloves had to be ordered from the US and they were not delivered in time to get all the tests done before the internship was over.

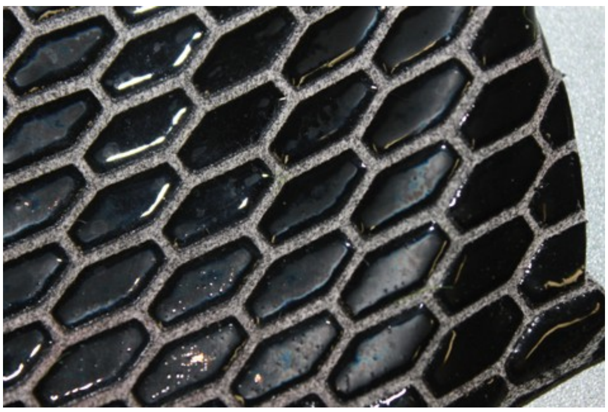

Figure 4.1: Details of the worn Gripworx glove

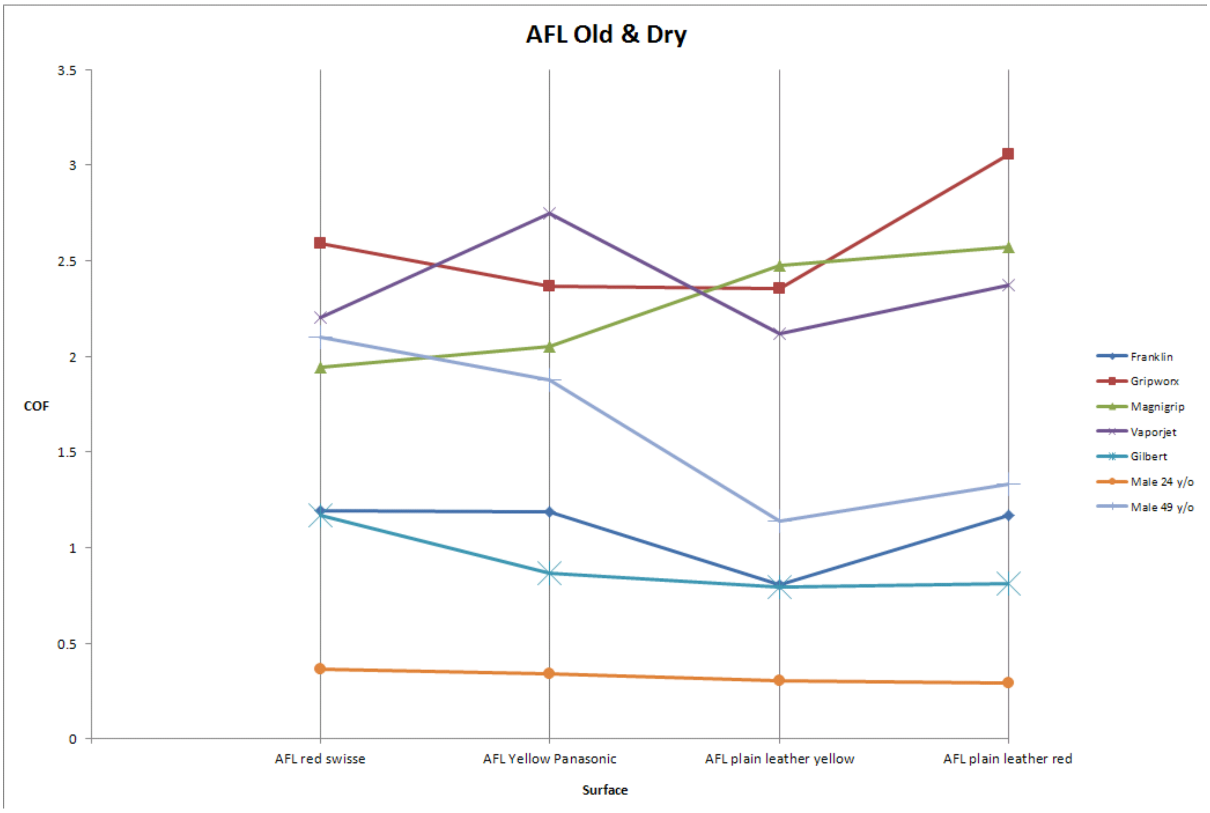

Figure 4.2: Results of the AFL surfaces for old gloves in dry conditions

4.1 AFL

For the AFL surfaces, two game ball patches and two plain leather patches used for making the balls were used. For the new gloves, ten different types were tested for the AFL in dry and wet conditions. Due to time constraints, only five of these gloves were tested in worn conditions, also in both the dry and the wet. These five were the leather Franklin glove, the Gripworx glove, with silicon patches on the palm, the Gilbert rugby glove, with pimples on the palm and the Nike Magnigrip and Vaporjet gloves with all silicon palms. **New pairs of the Nike gloves were however not delivered on time, so the tests for new gloves could not be executed before the internship was finished.**

4.1.1 Old gloves

In Figure 4.2, the results for old gloves in dry conditions are given, together with the results for the hand testing. From this it can clearly be seen that two Nike gloves and the Gripworx glove all are much better than the bare hand. This is probably due to the contact surface that is created by the flat silicone surfaces, whereas the Gilbert glove has higher pimples, reducing the contact surface with the leather of the ball. As will be shown below, these pimples are convenient for rugby, but not for AFL. The Franklin glove also performs a lot worse than the silicon gloves and this has to do with the fact that it is a completely different material and the interaction between leather and silicon is different from the interaction between leather and leather. Although the two hands tested were not from professional AFL players, it can be concluded that in the case the gloves are old, the gloves with silicon patches or all silicon palms will give a player a better grip on the ball and thus the ability to perform better. For some players the leather gloves or the glover with pimples will probably be an improvement, but considering that most players will be used to handling the ball, this improvement is most likely to be minimal.
For old gloves in wet conditions, shown in Figure 4.3 the performance of the gloves is in most cases worse, except for the Franklin leather glove. This glove is for three out of the four surfaces slightly better, and because of that it performs almost as well as the other gloves tested. The Gilbert glove again is far down compared to the other gloves and this is probably due to the contact surface created again. Another important thing to be seen in Figure 4.3 is the performance of the two hands. The hand of the 49 y/o performs better than all of the gloves and the hand of the 24 y/o is also a lot better and outperforms

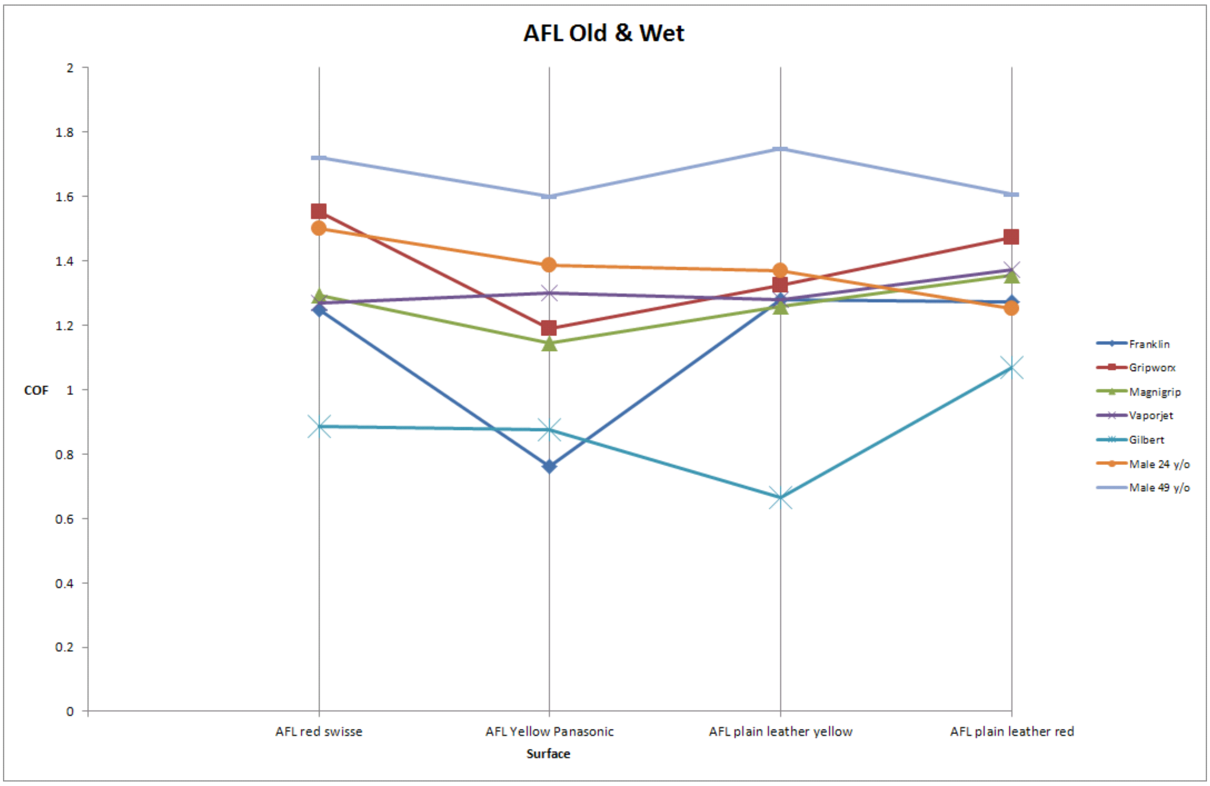

Figure 4.3: Results of the AFL surfaces for old gloves in wet conditions

the gloves slightly for the yellow leather and performs equally as good as most gloves for the red leather surfaces. This means that old gloves in wet conditions are not of significant use for a lot of players.

4.1.2 New gloves

For the new gloves, the results are given in Figure 4.4 and Figure 4.5. As said there were a lot more new gloves tested than old ones. The Nike Magnigrip tests could not be executed for both the dry and the wet conditions, while the Nike Vaporjet tests could only be done for dry conditions and not in the wet. With the new gloves in the figures, the results in dry conditions give a same trend as the results with the old gloves. The hand of the 24 y/o is at the bottom of the graph, so all gloves are better than that and the hand of the 49 y/o is in the middle, with the UA Blur II being consistently better over all surfaces and the Gripworx and Nike Vaporjet and Superbad better on two or three surfaces. These are again all the gloves tested that have an all silicon palm or silicon patches on the palm. The Gilbert Netball glove and the Grays Hockey glove, both with a thin polyester pattern on the palm, and the Gilbert Rugby glove all perform not that well, compared to the silicone gloves. Compared to the hand it depends greatly on which hand is tested. For the wet conditions, results for the new gloves are also in agreement with the old gloves. The hand of the 24 y/o again rises to a value above a lot of the gloves, only under the Gripworx and the UA Blur II. The hand of the 49 y/o has again the highest or second highest coefficient of friction. Both leather gloves, the Franklin and the Rawlings, have a higher coefficient of friction for the wet tests. Interesting to see is the Nike Superbad, which performs a lot worse in the wet conditions. This glove can be compared to the other two Nike gloves, which were tested for the old gloves. These also showed a big decrease in COF in wet conditions, although the values were still a lot higher for the Magnigrip and Vaporjet. This could be because of the old gloves that are a bit more rough already. All silicon gloves show a lot more of stick-slip behavior during the tests, so they are a lot more slippery in wet conditions. The Gilbert Rugby, Gilbert Netball and Grays Hockey gloves are performing a bit worse in the wet than in the dry. Only the Franklin and the Gripworx can really be compared for the wet conditions in old and new state and from the coefficients of friction it becomes clear that the Gripworx glove is structurally better than in the conditions when wet testing is done.
From both the tests in the wet and the dry, one can conclude that it is very dependent on the person if and which glove will bring you an advantage in AFL, but in general it can be said that the silicon

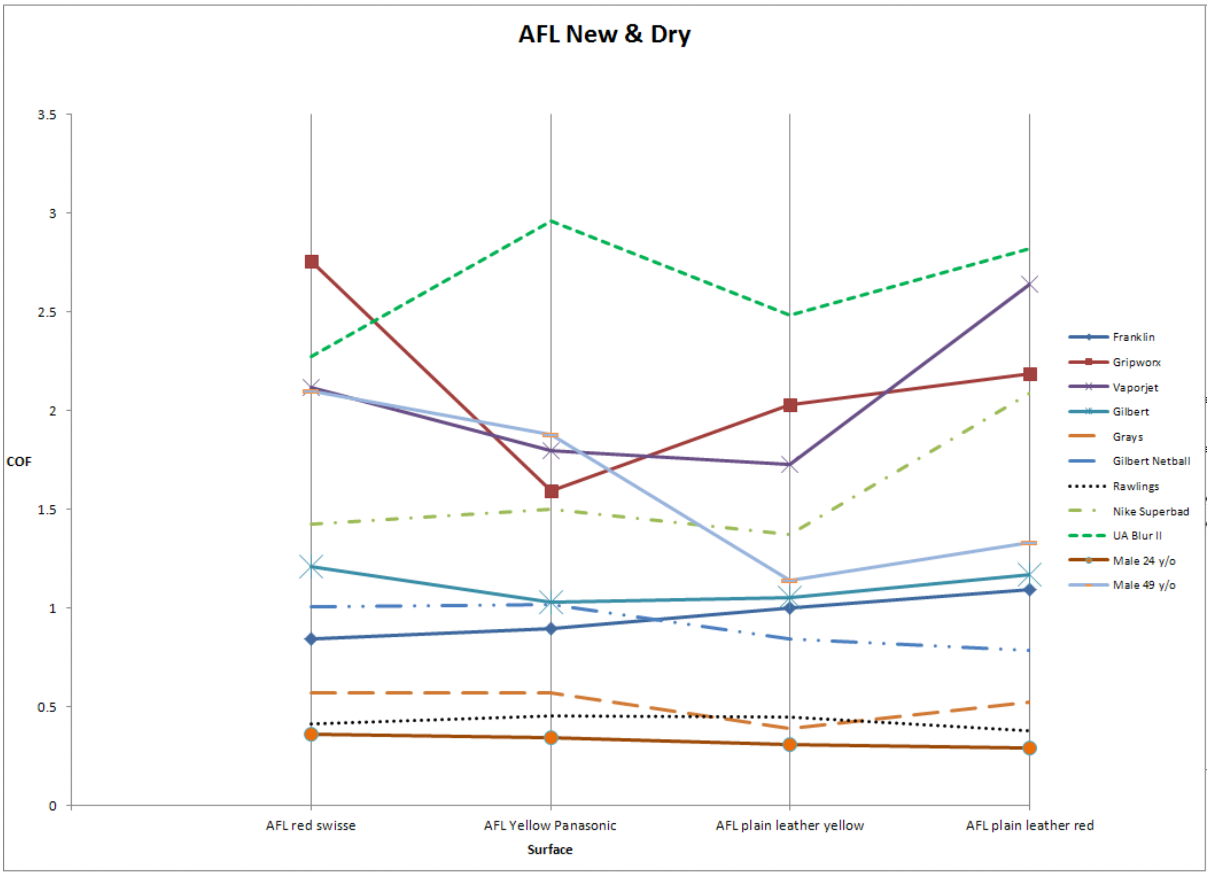

Figure 4.4: Results of the AFL surfaces for new gloves in dry conditions

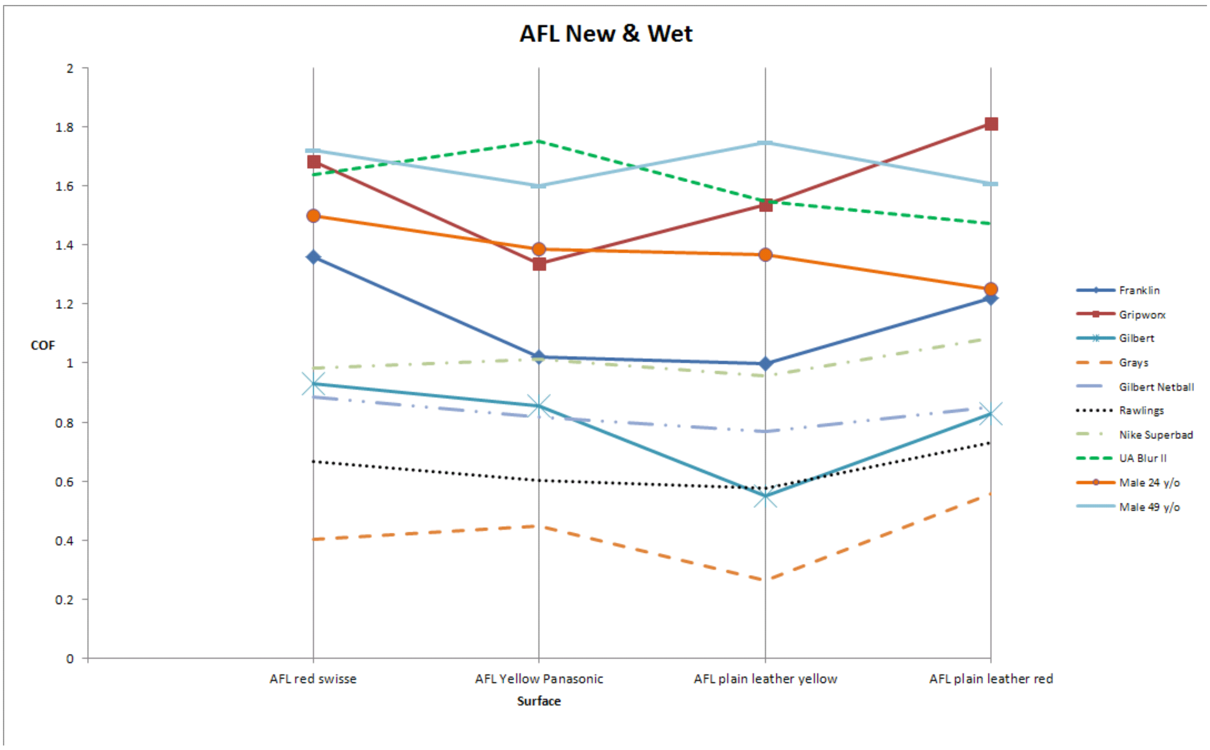

Figure 4.5: Results of the AFL surfaces for new gloves in wet conditions

gloves are definitely the best choice, with the UA Blur II and the Gripworx as the most constant in both the dry and the wet conditions. All other gloves can be better than the dry hand, but again there is a big dependency of which hand you are testing. The Gilbert Rugby, Gilbert Netball, Rawlings and Grays Hockey gloves all perform consistently bad, with a maximum coefficient of friction of 1.2 for all of these gloves. The Franklin glove gets better in the wet conditions, while the Nike Superbad significantly decreases in performance.

4.2 Rugby

For the rugby surfaces a total of five different gloves was tested on 10 different surfaces with different pimple patterns. As stated above, all surfaces can be found in Appendix B. The tests were done with old and new gloves and in dry and wet conditions.

4.2.1 Old gloves

In Figure 4.6, the results for old gloves on all surfaces in dry conditions are shown, together with the results for hand testing of both test persons. What can be seen is that for both smooth rubber surfaces, which are the two first surfaces in the figure, all five gloves are better than the two bare hands, but for the rest of the surfaces, one hand (49 y/o) is equally as good as the best glove or better and the other (24 y/o) is consistently better or equal to three of the gloves and equal or a bit lower than the other two gloves. the best two gloves are the Gripworx glove with the silicon patches on the palm and the Gilbert Rugby glove, with the pimples on the glove. The all silicon gloves and the leather glove are thus not performing as well as the two gloves with a combination of silicon patches and normal fabric like spandex. This is probably due to the surface interaction and the contact surface of the different gloves. Because the Gilbert Rugby glove has the pimples, it creates a lot more contact surface on the rugby surfaces with pimples than on both the smooth rubber surfaces and the AFL surfaces as previously seen. The silicon palm gloves are exactly the opposite. Because they are smooth themselves, the contact area becomes less when the surface is not smooth but pimpled. For a lot of the surfaces, the spread of the different gloves is also less then for the AFL surfaces.
In the wet tests, given in Figure 4.7 the trend seen with AFL shows again. The hand performance of both hands is better than almost all gloves on all surfaces. Seen again is the poor performance of the silicon gloves compared to the Gilbert Rugby glove. The Franklin glove also is significantly better in these wet conditions and is the second best glove for almost all surfaces. Also looking at the hand measurements, one can see that both hands have approximately the same behavior if one looks at the performance at different surfaces.

4.2.2 New gloves

For new gloves, the behavior and the results of the different gloves are comparable to the old gloves, as can be seen in Figure 4.8 and Figure 4.9. The Gilbert Rugby glove and the Gripworx glove are again performing best in dry conditions, ending up together with the hand measurements, while the Franklin and the Nike Vaporjet gloves are consistently performing worse. In the wet conditions there still is an advantage for both hands compared to the gloves for most of the surfaces. The Gripworx glove decreases again for the pimpled surfaces to values around the same values as the Franklin glove and the Gilbert glove stays around the same values.
Over all test conditions, a few things can be concluded. In dry conditions the Gripworx glove performs very well, but for the wet tests the results decrease significantly. The all silicon gloves that performed very well for the AFL surfaces do not seem to perform very well on the rugby surfaces and as said, this is thought to be a consequence of less contact surface. The Gilbert glove is very stable in the values of the COF, giving values between 1.5 and 1.8 for every surface in every condition. The reason for this constant behavior is again the pimples on both the surfaces and the gloves. In dry conditions this creates more contact surface and interlocking can occur between the two different pimples. Next to that, in the wet conditions, the pimples of the glove can get to the surface and create contact easier than a for example all silicon palm. The all silicon gloves therefore give a more slippery behavior in wet conditions. This leads to a conclusion that if one has to choose for a glove to wear for all weather conditions, this would be the Gilbert Rugby glove.

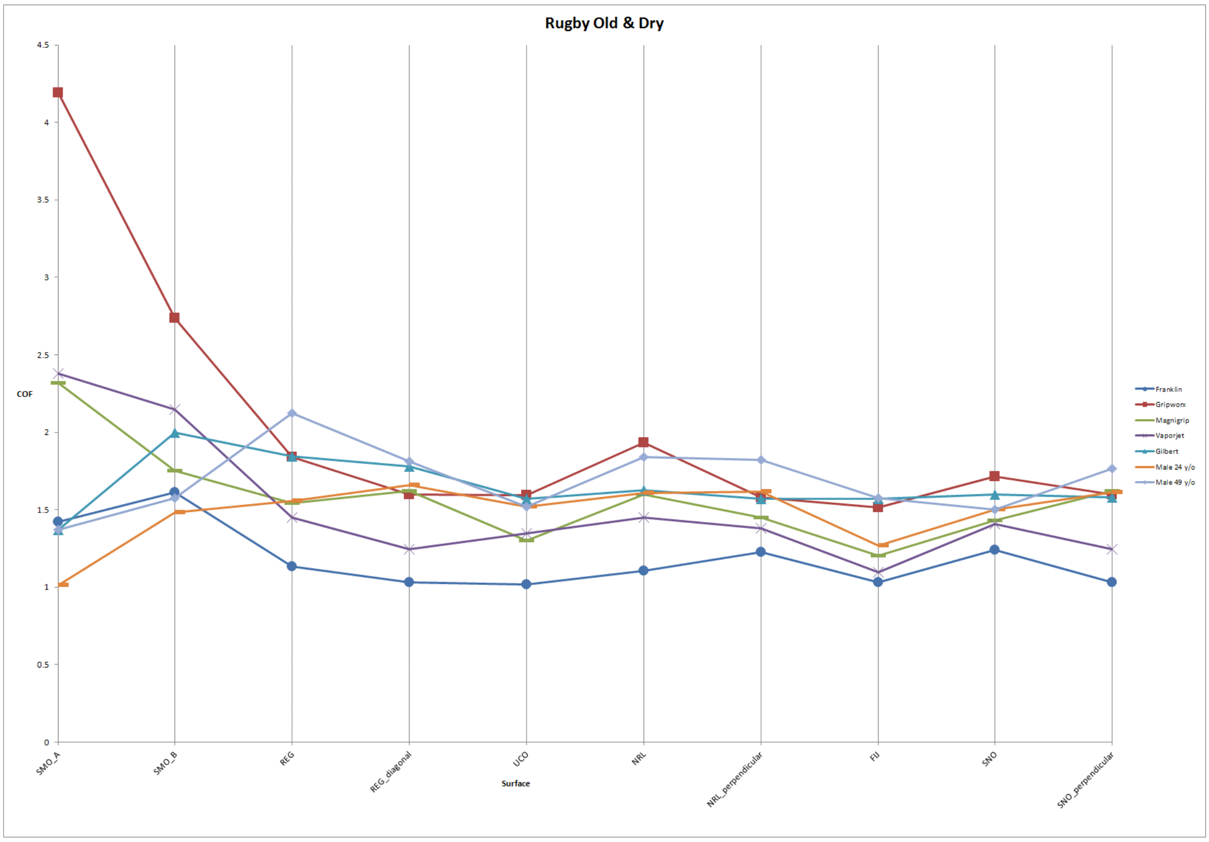

Figure 4.6: Results rugby surfaces for old gloves in dry conditions

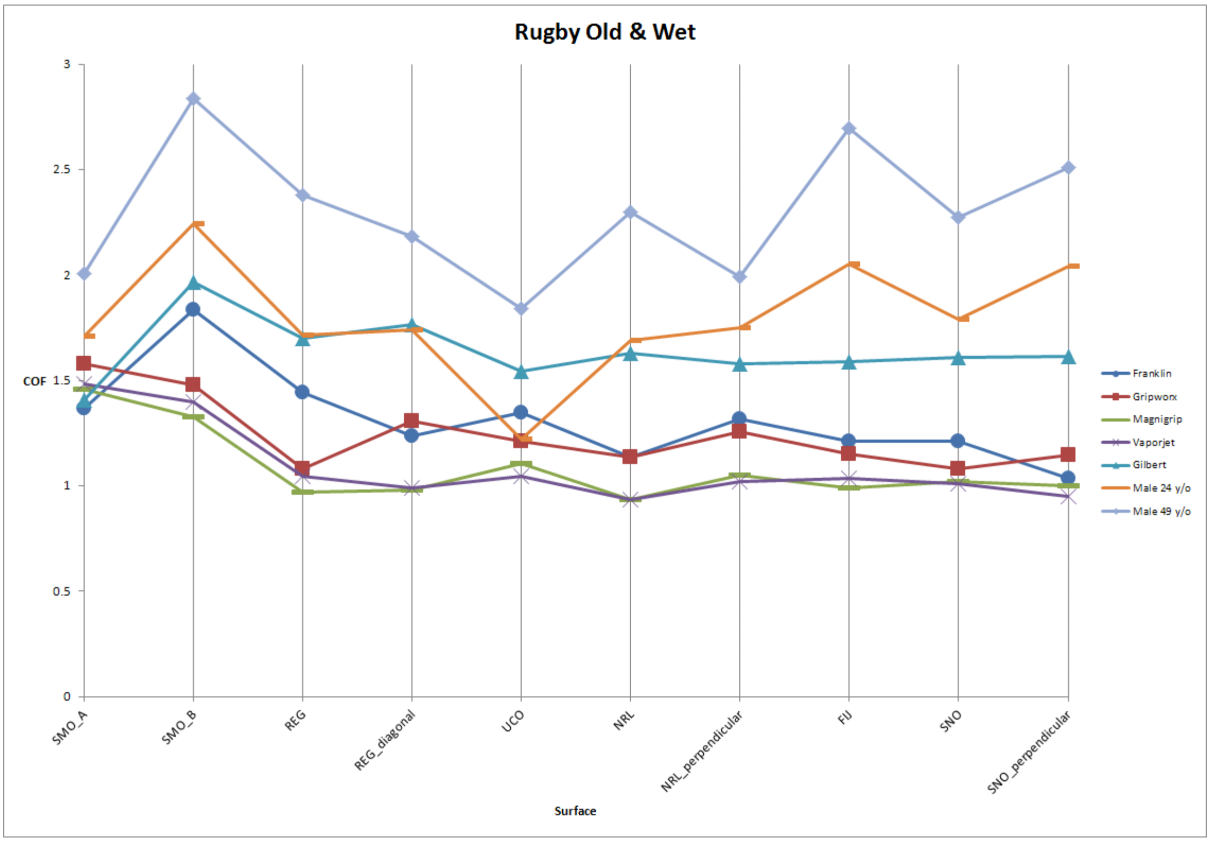

Figure 4.7: Results rugby surfaces for old gloves in wet conditions

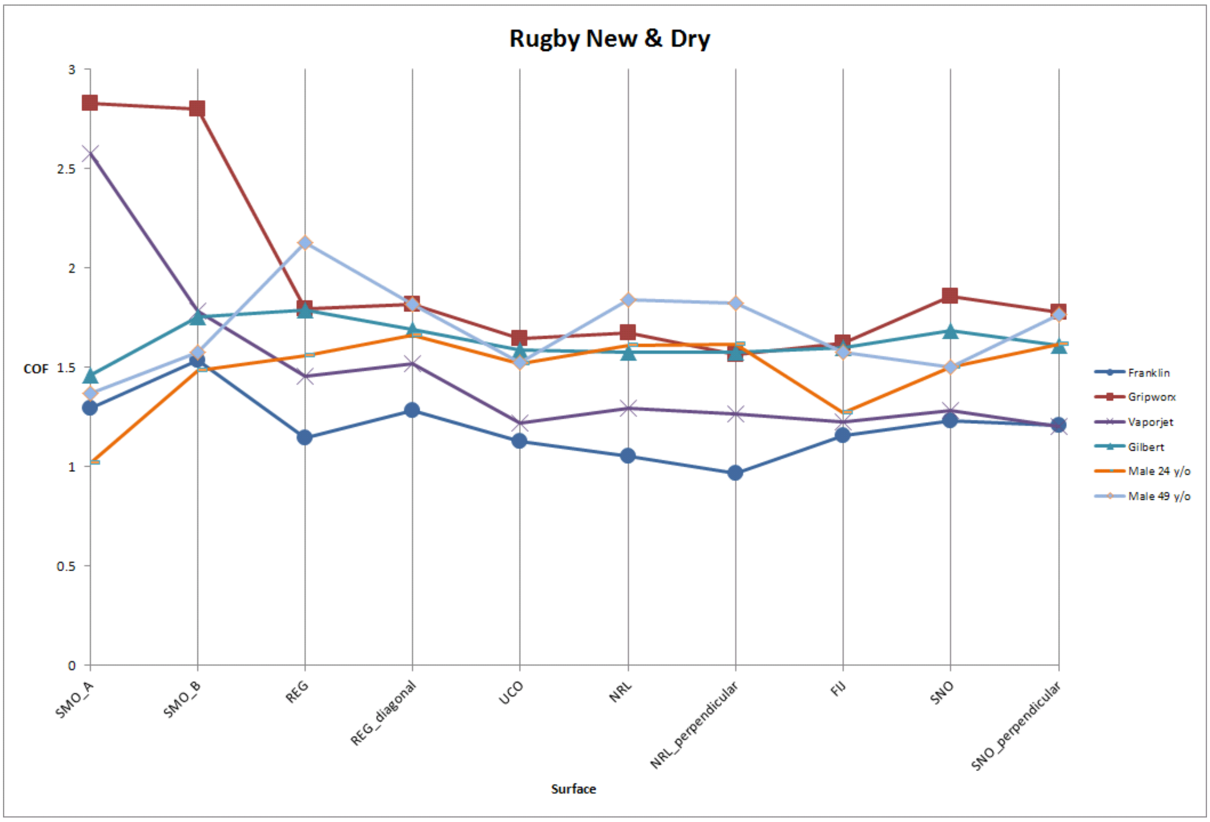

Figure 4.8: Results rugby surfaces for new gloves in dry conditions

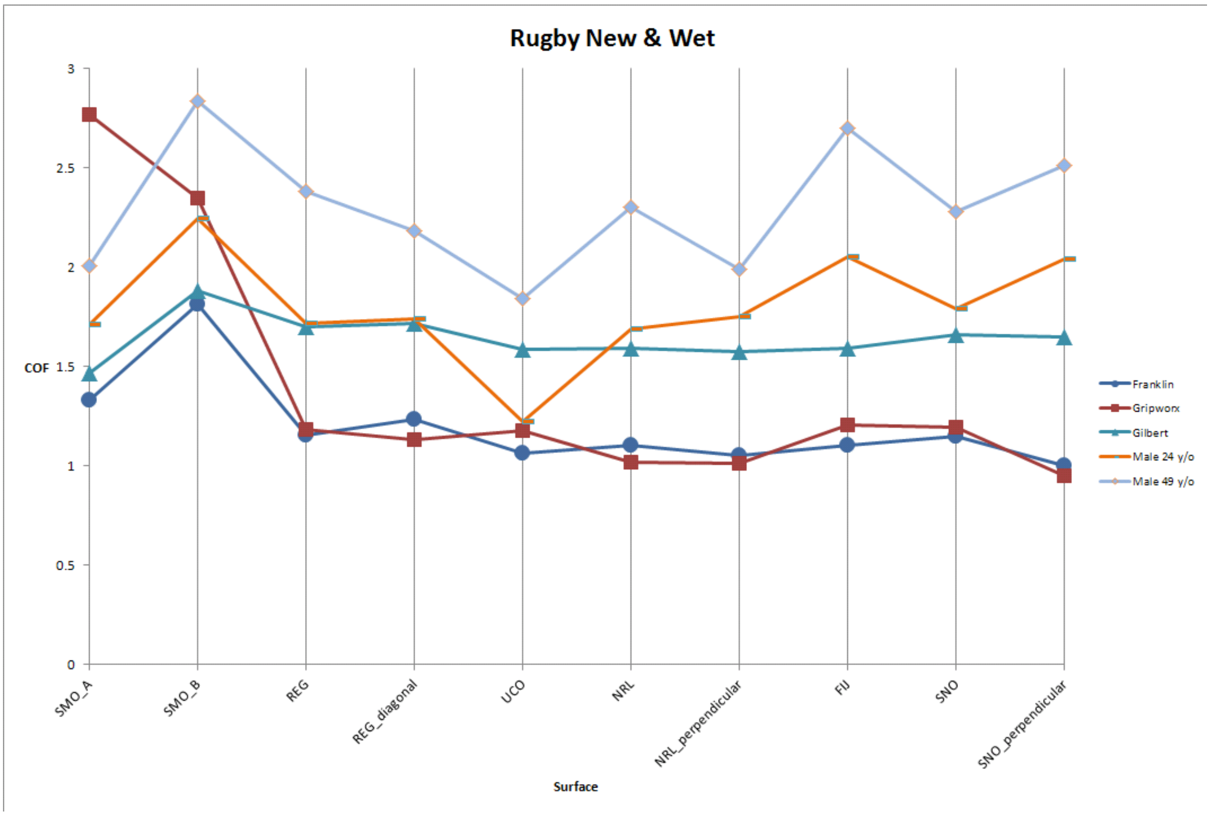

Figure 4.9: Results rugby surfaces for new gloves in wet conditions

With the results of the hands taken into account, the final conclusion can be drawn that wearing gloves is not really necessary from the results. Of course there are also psychological and personal aspects in the mix if it does make a difference for a player, but these were not taken into account for this research.

4.3 Individual gloves

4.3.1 Dry vs Wet

From the test results, it became apparent that some gloves perform better in the dry or in the wet. To show this graphically, seperate scatter graphs are made for each glove, showing the results in the dry on the horizontal axis plotted against the results in the wet on the vertical axis. Different series are made of old and new gloves, as well as AFL and rugby results. To make comparison a bit easier, all gloves with silicone are given in the first five figures, Figure 4.10 till Figure 4.14. These figures show the UA Blur II, which showed to be the best on AFL surfaces, the Gripworx glove, all three Nike gloves and the Gilbert glove, in that order. The first five all have all silicon palms or large silicon patches and if one looks at all these graphs, all results are on the dry side of the graph. This means that wearing silicon gloves is better in dry conditions than in wet conditions. All the gloves also show a trend in which the coefficient of friction develops. This trend is that the more sticky the gloves get, the more they are on the dry side of the line. For the Magnigrip and Vaporjet gloves, there is another clear conclusion to be drawn. For both of these gloves, all AFL points and two rugby surfaces are separated from the rest of the gloves. These two rugby surfaces are both smooth surfaces that were tested. From this it can be concluded that the gloves give a better result on smooth surfaces. The Gripworx glove (Figure 4.11) gives about the same results, although the points are a bit more scattered. All points that are outside of the big group of points are points of the AFL surfaces or the smooth surfaces.
For the Gilbert Rugby glove (Figure 4.15), the pattern is that it is very much on the line, so it behaves equally as good in dry as in wet conditions. As already concluded earlier, this makes that it is good to use this type of glove in all weather conditions.
In Figure 4.16 and Figure 4.17, the results for the two gloves with a thin silicone pattern on a spandex palm, the Gilbert Netball and the Grays Hockey glove, are given. These show a scattering around the line for equal behavior in dry and wet conditions, but for these gloves the COF results are not very high also.
The last two gloves are the Rawlings and the Franklin leather gloves. For the AFL surfaces they both show better results in the wet conditions, as opposed to the silicone gloves. For rugby surfaces only the Franklin was tested of these two and these results are often around the line of equal behavior, with the old glove performing slightly better in wet conditions and the new glove slightly better in dry conditions.
All this has to be compared with the behavior of the hands to be able to draw conclusions about the use of gloves. In Figure 4.20, the results for the hand can be seen and all these results tend very much to the wet side of the line. This means that the hand has more grip when the ball is wet. When this is compared to the gloves, one can conclude that in wet conditions, the bare hand is probably the best to use in both AFL and rugby. In dry conditions however, the silicone gloves come into play, because they have a very high coefficient of friction for especially the AFL surfaces. As shown in the previous section, in rugby they are not of great extra use at the moment.

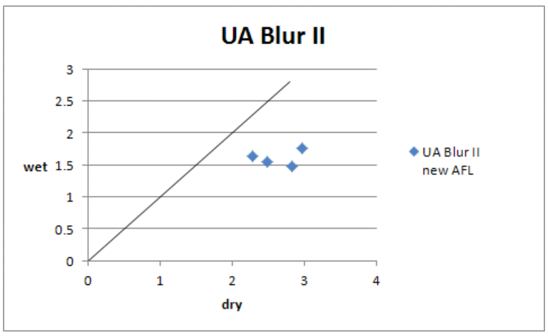

Figure 4.10: UA Blur II dry vs wet

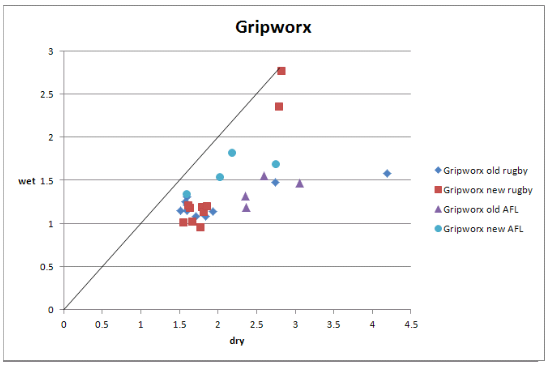

Figure 4.11: Gripworx dry vs wet

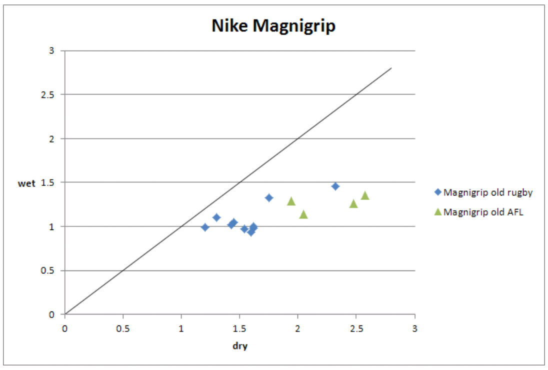

Figure 4.12: Nike Magnigrip dry vs wet

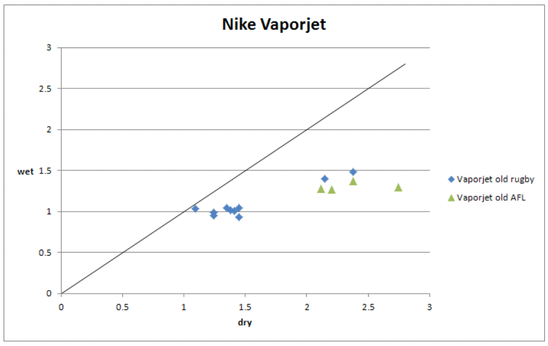

Figure 4.13: Nike Vaporjet dry vs wet

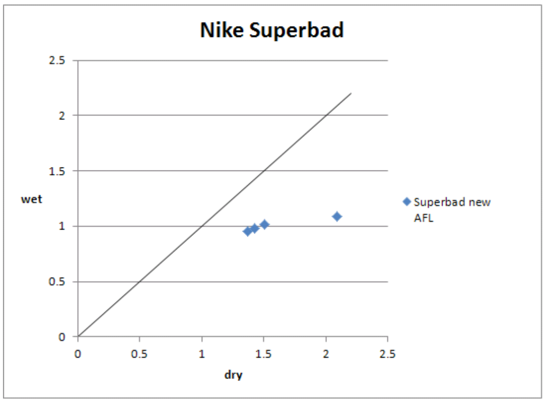

Figure 4.14: Nike Superbad dry vs wet

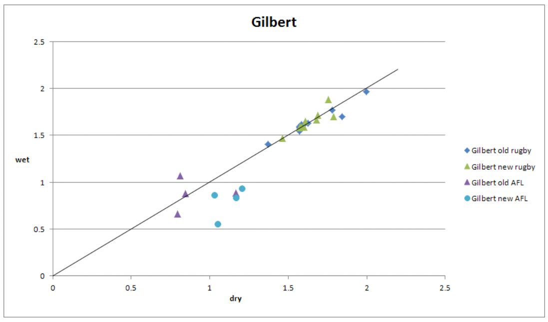

Figure 4.15: Gilbert Rugby dry vs wet

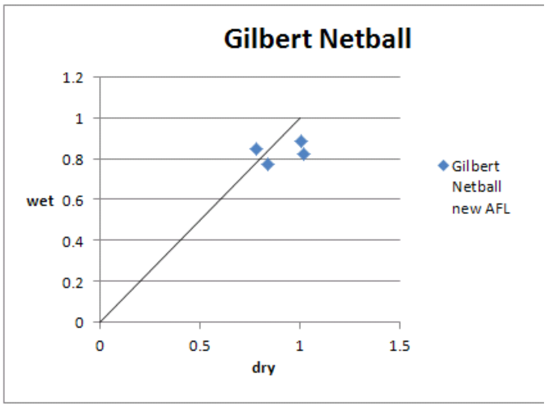

Figure 4.16: Gilbert Netball dry vs wet

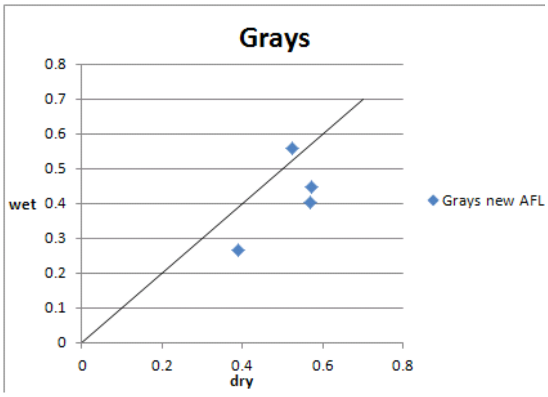

Figure 4.17: Grays Hockey dry vs wet

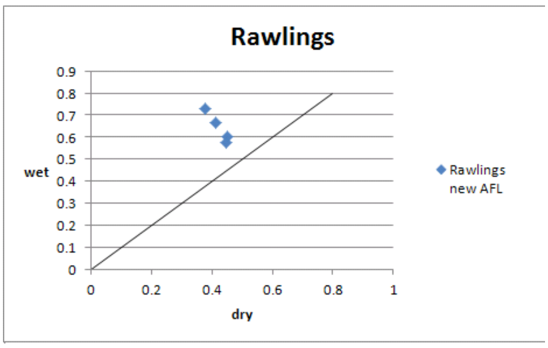

Figure 4.18: Rawlings dry vs wet

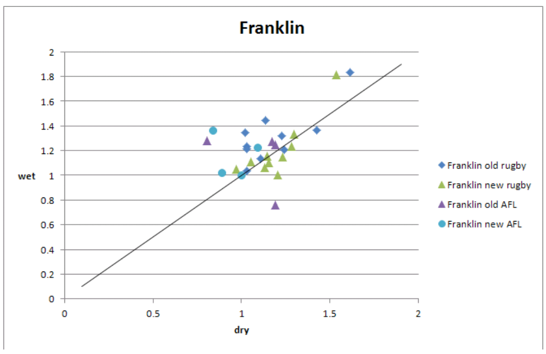

Figure 4.19: Franklin dry vs wet

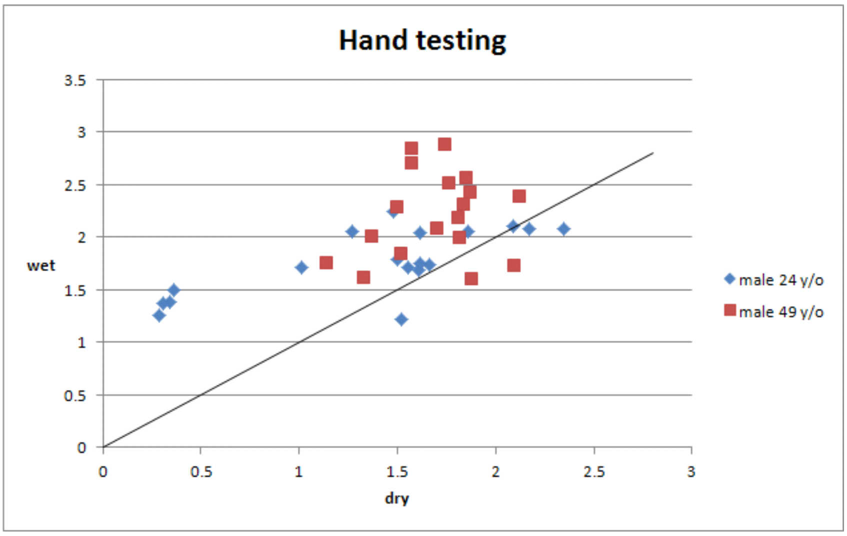

Figure 4.20: Hands

4.3.2 Old vs New

To compare the old and new gloves to each other, scatter graphs for these conditions are also given in Figure 4.21 till Figure 4.24. These figures show only the Franklin, Gripworx, Nike Vaporjet and Gilbert Rugby gloves, because these are the only gloves that were tested in old and new conditions at the moment. If one looks at the figures, there are less clear differences between old and new conditions than there were for dry and wet conditions. For the Franklin gloves, it looks like there is a slight preference for older gloves for the rugby surfaces in the wet, as well as for the AFL surfaces in the dry. The Gripworx glove has some more outliers. For the wet rugby tests, there are two points further out on the new side and those are both smooth rugby surfaces. The dry AFL data are giving a preference for old gloves for three out of the four surfaces and the rest of the combinations are around the equal performance line. For the Nike Vaporjet the trend for dry AFL and rugby looks the same as for the Gripworx and the two AFL tests that could be done display a preference for the old side, but this can not be conclusively said before more combinations are tested. The Gilbert Rugby glove is again very consistent in the equal performance between old and new gloves.

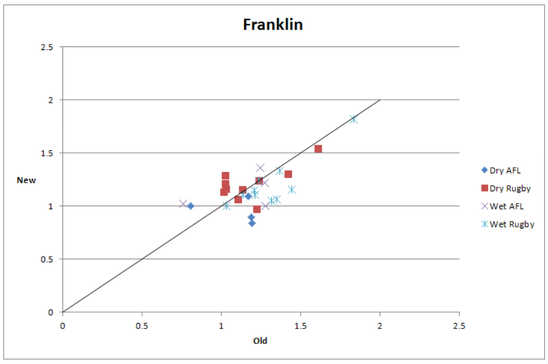

Figure 4.21: Franklin old vs new

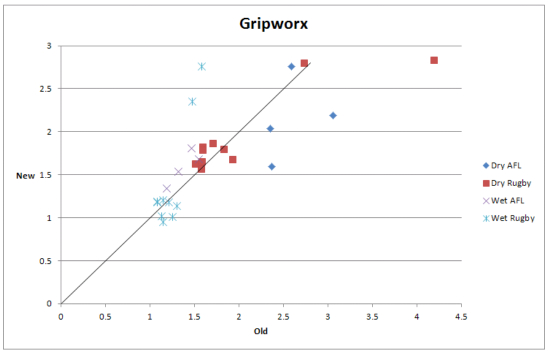

Figure 4.22: Gripworx old vs new

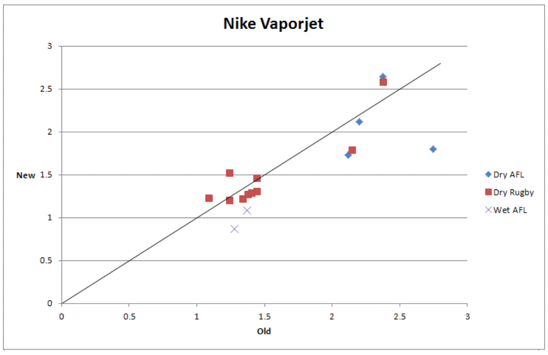

Figure 4.23: Vaporjet old vs new

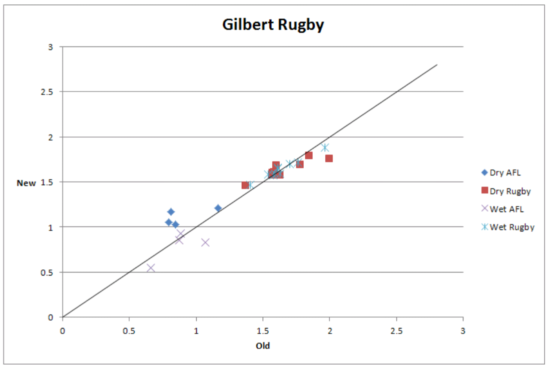

Figure 4.24: Gilbert Rugby old vs new

Chapter 5

Conclusions and Discussion

5.1 Conclusions

From all the results given above, a few conclusions can be drawn. These conclusions will again be divided into a part purely for AFL and a part for rugby. After that, some conclusions will be given about the individual gloves, both about old and new conditions and about dry and wet conditions.

5.1.1 AFL

This research was in the first place executed for the AFL in order to find a quantification of the advantage gloves have over using the bare hand. From the results we can conclude that the use of gloves is very dependent on the person and on the weather conditions played in, but also that some gloves have a very high coefficient of friction in dry conditions compared to results achieved with the bare hand. These gloves are the Nike Magnigrip, Nike Vaporjet, Nike Superbad, Gripworx Ironclad and Under Armour Blur II gloves. The biggest part of the palms of these gloves are all made out of silicone, while the other gloves are all made out of different materials. This leads to the conclusion that the gloves mentioned have a significant advantage over the use of the bare hand. For all other gloves it depends on the player that wears them if they have an advantage.
In wet conditions the hand performs better on the leather surfaces than in dry conditions. The results showed that the Gripworx and Under Armour gloves still were quite good, but the rest was not significantly better than the use of the bare hand and thus it can be concluded that gloves are of less use in wet conditions.

5.1.2 Rugby

In rugby the behavior of the gloves is shown to be different than the behavior in AFL. The hands perform a lot better compared to the gloves and the Gilbert glove also performs a lot better and is also very constant throughout testing the different surfaces. It is concluded that this is because of the contact area created between the glove and the surface. The all silicon palm gloves have a much bigger surface area on the smooth leather surfaces, as well as on the smooth rugby surfaces, but on the pimpled surfaces, they lose a lot of contact area, because they just rest on the pimples. The Gilbert glove however creates more contact surface on the pimpled surfaces, because the pimples can slide into each other to a certain degree. This is probably also the reason for the consistent results over all different pimpled surfaces for this glove.

5.1.3 Old vs New Gloves

When testing the gloves, they tend to show signs of wear after 20 measurements. The gloves that were available were tested also in worn off conditions and the results for this were not conclusive about weather old or new gloves have a better performance. The Gripworx showed a slight preference for new gloves on AFL surfaces and the outliers were again the smooth surfaces. The Gilbert glove showed a very equal performance again and the rest of the gloves were not showing a significant preference for old or new gloves.

5.1.4 Dry vs Wet

To see if gloves were better in wet or in dry conditions, scatter graphs have been shown and from this we can conclude that all gloves with a majority of silicon in the palm perform better in dry conditions, while the leather gloves perform better in the wet for the AFL surfaces, while the rugby surfaces showed to be on the line of equal behavior in dry and wet conditions. The Gilbert Rugby behaves the same for dry and wet, so it can be said that this is the best glove for all weather conditions. For the remaining two gloves, being the Gilbert Netball and Grays Hockey glove, there is no definite conclusion over the performance in dry or wet.

5.2 Discussion

5.2.1 Standardized Test Setup

To test the gloves in a standardized way, there has to be a test setup with which all gloves can be tested the same. This setup should consist of a force plate, possibly the one already used in the hand measurements. On the force plate, the surface and glove of interest have to be mounted. A weight element has to be put on the glove to exert a normal force and the glove has to be connected to an electric motor that can pull the glove over the surface. The motor used in this case is a Roycecross geared electric motor (Product code PGM70R6-15W) with a maximum torque of 5 Nm, a speed of 6 rpm and a gear ratio of 250:1. The way the measurements are carried out is the same as the initial testing with the hand. Unfortunately, this part of the project could not be finished in time, so this is one of the next steps due to be taken in the project. To be able to tell the quantitative differences between worn gloves and new gloves, there also has to be an automated setup, which can wear off the gloves, so there should be a friction mechanism like a treadmill on which the glove is mounted for some time.

5.2.2 Force measurements

The force measurements also did not materialize in the right time frame, because the instrumentation in the ball broke down during testing. This part of the research is at the point where it is going to be tested in the very near future, leading to a better insight of the forces acting on the ball and the hand during the game. Further development of the ball and the glove subsequently has to be done to make it more standardized than it is now, for example by getting a standard instrumented ball from the manufacturer.

5.2.3 Comfort

A property that can not be researched, because it is subjective from one person to another is the comfort of the different gloves. This has also a big influence on which glove a certain player wants to wear and it is regardless of the actual performance of the gloves. When a player does not feel comfortable wearing a certain glove, this will mean that he is less confident and as a consequence will probably play worse than without a glove. As said, this property is very subjective and depends on the player and maybe even on the circumstances and therefore it is not regarded as a research parameter.

5.2.4 Wet Testing

The amount of water used in the wet testing phase may be a bit high, but it was only to get a good idea of the differences between the gloves in different circumstances. To map the whole behavior of the gloves, it may be a good idea to do more tests with different amounts of water when the standardized test setup is designed and working properly.

5.2.5 Hand Testing

The hand testing was done by two different people. Because hands are unique, these two hands are no real good average of a normal hand, especially because the two hands are also far from each other. To get a better insight into hand behavior, more hands could be tested and possibly also with actual players of AFL and rugby.

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Appendix A

Gloves

Below you will find an overview of the gloves tested, with details.

Figure A.1: The Franklin glove used in the testing

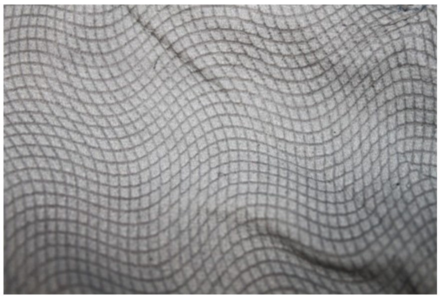

Figure A.2: Detail of the Franklin glove

Figure A.3: Worn Franklin glove

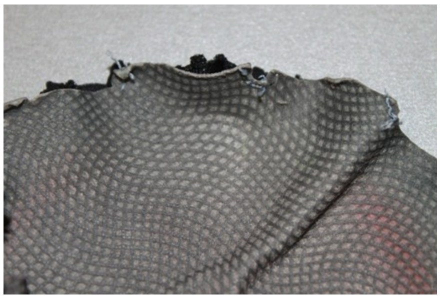

Figure A.4: Detail of the worn Franklin glove

Figure A.5: The Gripworx glove used in the testing

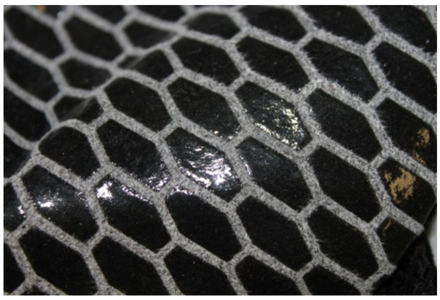

Figure A.6: Detail of the Gripworx glove

Figure A.7: Worn Gripworx glove

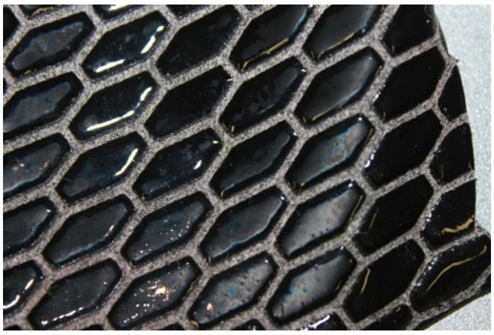

Figure A.8: Detail of the worn Gripworx glove

Figure A.9: Worn Nike Magnigrip glove

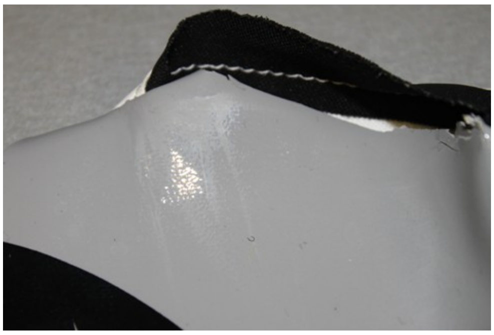

Figure A.10: Detail of the worn Nike Magnigrip glove

Figure A.11: Worn Nike Vaporjet glove

Figure A.12: Detail of the worn Nike Vaporjet glove

Figure A.13: Gilbert rugby glove

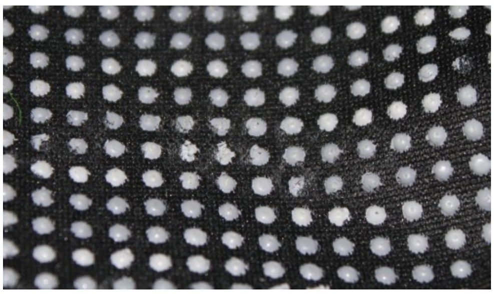

Figure A.14: Detail of the worn Gilbert rugby glove

Figure A.15: Grays Hockey glove

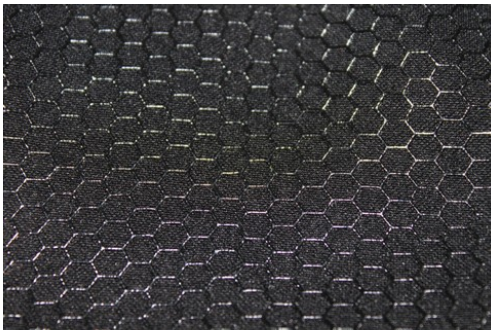

Figure A.16: Detail of the Grays glove

Figure A.17: Gilbert Netball glove

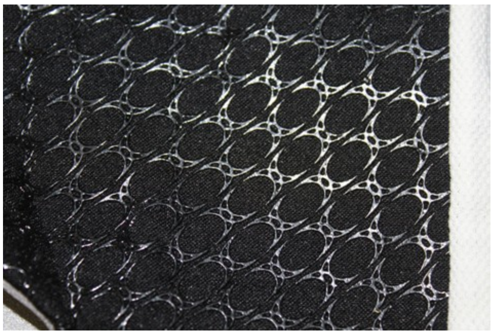

Figure A.18: Detail of the Gilbert Netball glove

Figure A.19: Nike Superbad glove

Figure A.20: Detail of the Rawlings glove

Figure A.21: Under Armour Blur II Glove

Appendix B

Surfaces

Below there is an overview of all the surfaces tested, with the details.

Figure B.1: Red patch of an official ball

Figure B.2: Yellow patch of an official ball

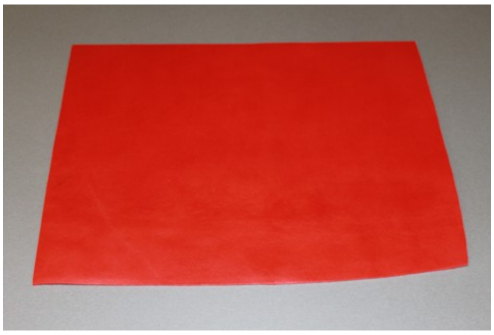

Figure B.3: The patch of plain red leather

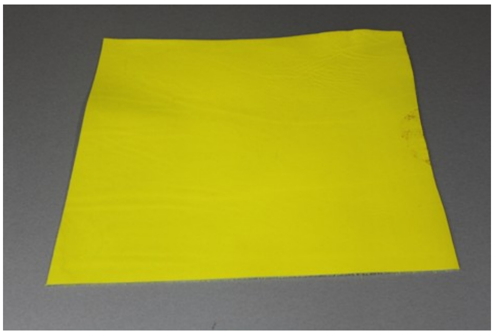

Figure B.4: The patch of plain yellow leather

Figure B.5: The patch of the first plain rubber surface

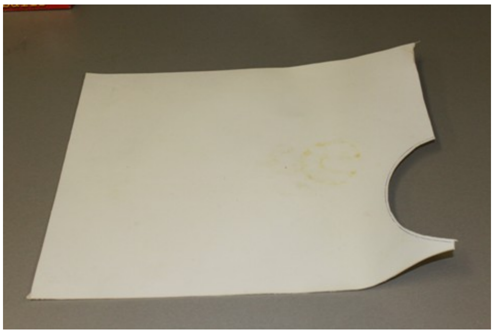

Figure B.6: The patch of the second plain rubber surface

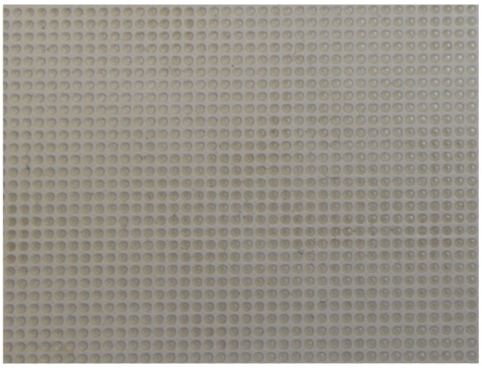

Figure B.7: Detail of the experimental Regular pattern

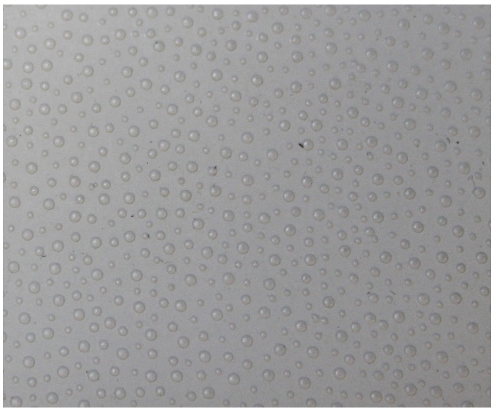

Figure B.8: Detail of the Rugby Union pattern

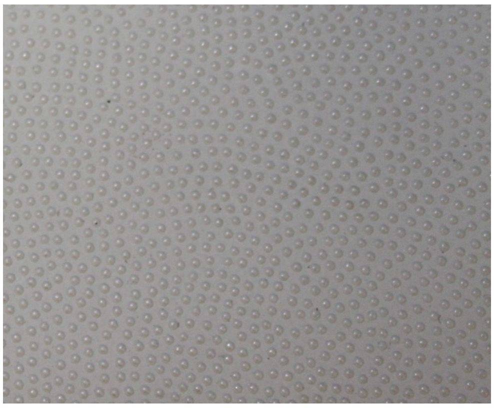

Figure B.9: Detail of the National Rugby League pattern

Figure B.10: Detail of the Fine Japanese pattern

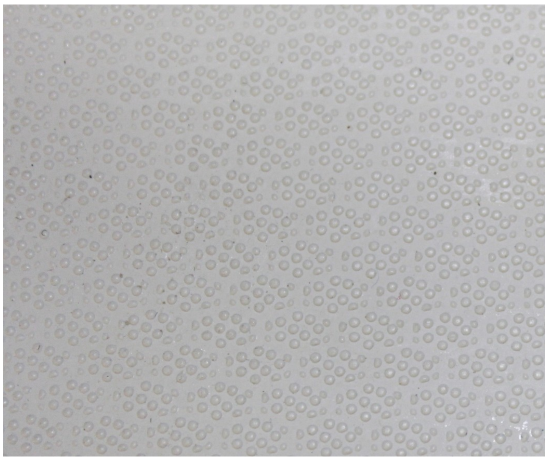

Figure B.11: Detail of the Snowflake surface

Appendix C

Coefficients of Friction

In the tables underneath all values of the coefficient of friction for all different combinations are given. Here μ means the coefficient of friction and the subscripts are Franklin, Gripworx, Nike Magnigrip, Nike Vaporjet, Gilbert, Grays, Gilber Netball, Rawlings, Nike Superbad and Under Armour respectively.

Surface	old/new	dry/wet	μ_F	μ_G	μ_{NM}	μ_{NV}	μ_{Gil}	μ_{Gr}	μ_{GilN}	μ_R	μ_{NS}	μ_{UA}
Yellow Ball	old	dry	1.1894	2.366	2.0492	**2.7466**	0.8468					
Yellow Ball	old	wet	0.7614	1.1882	1.1422	**1.2992**	0.8756					
Yellow Ball	new	dry	0.8936	1.5936	1.5112	**1.7952**	1.0308	0.5722	1.0202	0.4528	1.503	2.9616
Yellow Ball	new	wet	1.0194	1.3364			0.856	0.447	0.819	0.6038	1.0126	1.7506
Red Ball	old	dry	1.1928	**2.592**	1.9424	2.2032	1.1658					
Red Ball	old	wet	1.2464	**1.5486**	1.2924	1.2672	0.885					
Red Ball	new	dry	0.8408	**2.7578**	2.6034	2.12	1.2094	0.57	1.0058	0.4136	1.4254	2.2742
Red Ball	new	wet	1.358	1.6826			0.9298	0.4022	0.8846	0.6658	0.9822	1.6366
Plain Yellow	old	dry	0.8062	2.3522	**2.4732**	2.1182	0.7948					
Plain Yellow	old	wet	1.2778	**1.3212**	1.2576	1.2778	0.6626					
Plain Yellow	new	dry	1.0014	2.0332		1.7266	1.0534	0.389	0.8444	0.448	1.3704	2.482
Plain Yellow	new	wet	0.9984	1.5344		0.8676	0.5504	0.2654	0.7696	0.5772	0.9554	1.5474
Plain Red	old	dry	1.1708	**3.0564**	2.5744	2.3754	0.8102					
Plain Red	old	wet	1.2726	**1.4704**	1.3544	1.3722	1.0666					
Plain Red	new	dry	1.0938	2.1856		2.6442	1.1708	0.524	0.7874	0.3798	2.0876	2.8228
Plain Red	new	wet	1.2182	1.8114		1.0816	0.8302	0.5576	0.8496	0.7296	1.0838	1.4722

Table C.1: Overview of the coefficients of friction for AFL surfaces

Surface	old or new	dry or wet	μ_F	μ_G	μ_M	μ_V	μ_{Gil}
SMO A	old	dry	1.424	**4.1924**	2.3192	2.3794	1.3696
SMO A	old	wet	1.3682	**1.5792**	1.46	1.4844	1.4052
SMO A	new	dry	1.2956	2.8274		2.5742	1.4614
SMO A	new	wet	1.3306	2.7626			1.4682
SMO B	old	dry	1.6142	**2.7384**	1.7542	2.1492	1.9968
SMO B	old	wet	**1.8344**	1.4786	1.3264	1.3972	1.964
SMO B	new	dry	1.5342	**2.7952**	1.8778	1.7782	1.7534
SMO B	new	wet	1.8144	2.3476			1.8798
REG	old	dry	1.1352	**1.8396**	1.542	1.4492	1.8442
REG	old	wet	**1.4442**	1.0798	0.9718	1.0448	1.6992
REG	new	dry	1.1468	**1.7942**	1.6682	1.4532	1.7888
REG	new	wet	1.1532	1.1812			1.6972
REG diagonal	old	dry	1.03	1.5978	**1.62**	1.2434	1.7792
REG diagonal	old	wet	1.234	**1.3064**	0.9808	0.9874	1.765
REG diagonal	new	dry	1.284	1.8158		1.5182	1.6902
REG diagonal	new	wet	1.2358	1.1324			1.7138
UCO	old	dry	1.0198	**1.5944**	1.301	1.3464	1.5726
UCO	old	wet	**1.347**	1.211	1.1046	1.0434	1.5416
UCO	new	dry	1.1296	**1.6442**	1.4622	1.2158	1.5834
UCO	new	wet	1.0614	1.1754			1.5846
NRL	old	dry	1.1074	**1.934**	1.5988	1.4488	1.6256
NRL	old	wet	**1.135**	1.1348	0.9348	0.9354	1.6296
NRL	new	dry	1.0538	1.6728		1.2954	1.5748
NRL	new	wet	1.1052	1.0162			1.5916
NRL perpendicular	old	dry	1.2256	**1.5792**	1.452	1.3808	1.5716
NRL perpendicular	old	wet	**1.317**	1.2546	1.052	1.0194	1.5778
NRL perpendicular	new	dry	0.968	1.5606		1.2674	1.5722
NRL perpendicular	new	wet	1.0504	1.0106			1.5762
FIJ	old	dry	1.0318	**1.5138**	1.2014	1.0952	1.5696
FIJ	old	wet	**1.2106**	1.1486	0.9896	1.0352	1.5908
FIJ	new	dry	1.1532	1.6214		1.226	1.5988
FIJ	new	wet	1.1034	1.2044			1.5892
SNO	old	dry	1.2426	**1.7162**	1.4308	1.4098	1.5984
SNO	old	wet	**1.209**	1.0828	1.0188	1.0078	1.6092
SNO	new	dry	1.2326	1.8582		1.2798	1.6812
SNO	new	wet	1.1496	1.1918			1.66
SNO perpendicular	old	dry	1.03	1.5978	**1.62**	1.2434	1.5822
SNO perpendicular	old	wet	1.0342	**1.1474**	0.9978	0.9474	1.6116
SNO perpendicular	new	dry	1.2064	1.778		1.1998	1.61
SNO perpendicular	new	wet	1.003	0.9504			1.65

Table C.2: Overview of the coefficients of friction for rugby surfaces

Surface	24 y/o dry	24 y/o wet	49 y/o dry	49 y/o wet
Yellow Ball	0.342	1.3838	1.879	1.599
Red Ball	0.36225	1.4982	2.0998	1.7198
Plain Yellow	0.3062	1.368	1.1376	1.7474
Plain Red	0.2896	1.2516	1.3316	1.6054
SMO A	1.015	1.7118	1.3692	2.0068
SMO B	1.4824	2.2448	1.5756	2.835
REG	1.5576	1.713	2.1246	2.3802
REG diagonal	1.661	1.7388	1.8134	2.1822
UCO	1.5192	1.222	1.5208	1.8426
NRL	1.6062	1.688	1.8412	2.3
NRL perpendicular	1.6174	1.7502	1.8208	1.989
FIJ	1.2684	2.0518	1.5748	2.6982
SNO	1.5018	1.7916	1.5018	2.2745
SNO perpendicular	1.6126	2.0412	1.7654	2.5094

Table C.3: Overview of the coefficients of friction for the different hands tested