Research Project

Fontys University of Applied Sciences

Physiotherapy English Stream

Goniometric measurements of hip range of motion related to the backswing in football.

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Table of content

Abstract

Background

Research suggests that classical range of motion (ROM) testing of the hip does not take into account the sport specific movements [11- 12]. This is because classical ROM testing is being done in one or two planes of movement and therefore lacks 3 dimensional (3D) characteristics. Due to adaptations the football player may show different hip ROM behavior in different directions compared to non-football players. In case of kicking related injuries such as groin injury the football player should be tested in positions which represent the kicking biomechanics. The question however is whether testing ROM of the hip in kicking specific positions does result in different outcomes in comparison to the standard way of testing.

Aim: This study is attempting to find out whether a more specific way of testing ROM in football players is viable for the diagnosis and screening process of groin-related injuries.

Method

For the experiment two groups of 15 volunteers was selected. One group consisted of experienced football players while the other groups were not playing football.
The hip joint were tested in 3 different situations, Viz in standard position, in hip extension and in hip extension combined with trunk rotation.
In each situation the ROM of abduction, adduction, internal rotation and external rotation was measured using a universal goniometer.
The whole measurement protocol was repeated once for an at random selected test subject in each group the day after the original test in order to determine the repeatability. After collecting the data, it was statistically analyzed using the Independent t-test and Pearson correlation test.

Results

No statistically significant differences were found between the data of the two groups except for abduction in hip extension.
The intra – tester reliability showed excellent Pearson correlation results being (P=) 0.978 for football players and (P=) 0.989 for non-football players.

Conclusion

Although hardly any differences were found when comparing the two groups tested, further research is warranted due to the small sample of persons tested and drawbacks in the experimental approach.

Introduction

Groin injuries are one of the most prevalent lower limb injuries in sport activities.[1] In general groin complaints make up 2-5% of all injuries in sport. The resulting pain is very often frustrating for the athletes who participate in activities involving sprinting, quick acceleration and deceleration movements. The most frequent cause of groin pain in the athletic population is coming from an adductor strain. This leads to lost play time in many different sports [2-3-4]. Especially among football players groin complaints are very common. There have been reported prevalence rates as high as 10-18 groin injuries per 100 football players, and out of these 62% were diagnosed with adductor strains. This is because the adductors are especially critical when there are great demands of strong eccentric contraction. Out of this muscle group the most common muscle to get injured is the adductor longus. Adductor injuries can occur at the muscle origin or insertion, at the muscle tendon junction or in the muscle belly of the muscle(s) [5].The anatomical structure where adductor tears usually occurs is in the muscle- tendon junction, but there are exceptions and sometimes the tendon injury can occur at the site of its bony attachment.

Tyler et al. [6] discovered that in their study National Hockey League (NHL) ice hockey players suffering from a groin injury during the season had 18% less adductor muscle strength during preseason than uninjured players. The strength ratio between adduction and abduction were also different between the two groups, with the injured players showing a deficit in adductor strength. Furthermore, the players who suffered a groin injury presented a lower adduction and abduction strength ratio on the injured side compared to the uninjured side.

An important aspect in regards to groin injuries is the fact that football kicks or maximal instep kick demand a lot of adductor muscle strength and this in turn contributes to higher risk of groin overload. [7] Two studies showed that the kicking leg was more often injured than the non-kicking leg implying that kicking may be part of the problem [8-9].

During a maximal instep kick the backswing phase is crucial and this is the moment with the highest risk of adductor strain [8, 10]. The backswing phase starts when the toe of the kicking leg leaves the ground. After leaving the ground the kicking leg moves into hip extension with the hip extending on average 29°. This results in a pre-stretch of the iliopsoas and the adductor muscles.

The backswing phase continues until maximal hip extension is reached, which occurs right after the supporting leg hits the ground.

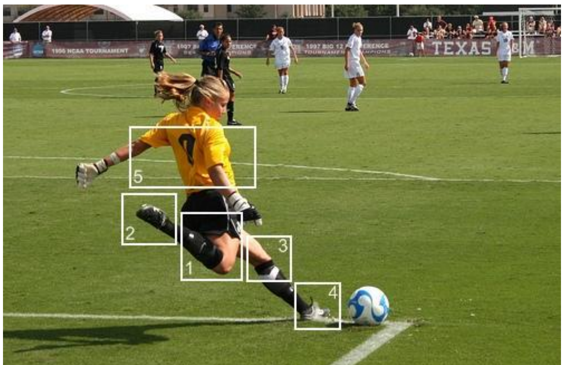

Figure1.
The backswing in a maximal instep kick. This picture was found on the internet.

The tension arc involves hyper extension of the hip and knee flexion on the kicking side, contralateral trunk rotation and shoulder extension and abduction of the non-kicking side. The release of the arc is done by a whip like motion of the kicking leg, the trunk goes into ipsilateral rotation and on the non-kicking side flexion and adduction occur in the shoulder. The tension arcs primary role is to effectively

utilize the cycle of stretch-shortening needed to generate maximum power output of the kick.
In a study by Igor Tak and Rob Langhout[11] they observed a correlation between a larger range of full body backswing and the velocity of the ball.
Igor Tak and Rob Langhout discovered that if the backswing flexibility was diminished the football player had to compensate and use a different kicking strategy that involved higher muscle activation of the hip and knee muscles. This could potentially place them at higher risk of injury. From this discovery hip range of motion (ROM) should be examined in an extension position of the hip but also with a rotated upper body.
Some research suggests that classical ROM testing of the hip does not take into account the sport specific movements[11-12].This is because classical ROM testing is being done in one or two planes of movement and therefore lacks 3 dimensional (3D) characteristics. Igor Tak and Rob Langhout started a more functional assessment of the hip ROM that involved the trunk, hip and leg mimicking the 3D characteristics of the backswing in football. This resulted in the football players being tested with their trunk in contralateral trunk rotation and knee in flexion. Unfortunately they have yet to publish any data from their research study.
As described the body is in a different position when performing a maximal instep kick and classical ROM testing does not come close to this specific position. Hence one should address this issue and try to measure hip ROM in football players in 3D positions.
Additionally, anatomical adaptations from the years of sport practice might influence the results of normal ROM testing of joints and should possibly be adapted to its specific conditions. Due to adaptations the football player may show different hip ROM behavior in different directions compared to non - football players. In case of kicking related injuries such as groin injury the football player should be tested in positions which represent the kicking biomechanics. This is not being done in practice because this has never been properly tested until Igor Tak and Rob Langhout did it.
As this is such a new concept there is a gap of knowledge. A more specific way of testing could be discovered. This could provide added value to the daily work of a physiotherapist and provide a more detailed view of the injury scope and consequently make physiotherapists able to do better treatment because they can work in a specific ROM pattern where the injury took place.
This study attempted to compare the standard way of testing ROM with the new concept of sport specific ROM in football players.
The primary aim of this study was to find the difference between the two groups with regards to ROM and discover possible functional adaptations due to the many years of playing football.
It is hypothesized that there will be a difference between non-football players and football players ROM due to functional adaptation for the football players resulting in increased range of motion

This lead to the research question:
“What effect does putting the hip in extension and the trunk in rotation have on ROM testing of the hip (internal/external rotation and abduction/adduction) in football players versus non- football players?”

Method

Study design

This study was based on an experimental approach in which healthy football players and non- football players took part.

The testing of subjects was done in football clubs in the Eindhoven area and at Fontys University of Applied Sciences in Eindhoven in a booked classroom. All subjects were tested with the same procedure. The test subjects measured at the football clubs facilities were supervised by the physiotherapist of the club.

Variables

The variables measured were hip ROM in abduction, adduction, internal rotation and external rotation of the two groups measured with a universal goniometer. All test subjects were tested on the dominant leg.

Subjects

There were two groups consisting of 15 test subjects each; football players and non-football players. Test subjects were recruited via email. In the email the participants were given information about the study, and the criteria the subjects should have met in order to be able to participate in the study. (**See appendix I)**

The group with the football players was recruited from Woenselse boys playing in the 4th division in Eindhoven.

Inclusion criteria for the football group: test subjects had to be males between 16 – 30 years old and play football minimum twice a week for at least 5 years. The age limit was set due to the non – football players being relatively young and therefore we needed to have a correlating age between the groups. The requirement of having played football for at least 5 years was to ensure that the thought functional adaptations were given time to occur.

Unfortunately this research did not record any demographic data of the test subjects such as age, height, BMI and playing experience. The researcher only checked the age to make sure the test subjects were within the criteria of participation.

Test subjects in the non-football group were recruited from Fontys Paramedische Hogeschool. Inclusion criteria for the non- football playing group were that they had to be physically active minimum twice a week. This criterion was put in order to ensure that the non-football players were in the same amount of activity as the football player group, and this in turn ensures a homogenous group.

General exclusion criteria were: Females, illness and having sustained an injury to the hip or groin in the last three months. All participants in the study were asked to sign a written informed consent **(See appendix I)** at the beginning of the experiment.

Measurement tools

The ROM of the two patient groups was measured with a goniometer because it is more practical than an inclinometer when measuring so many test subjects.

An inclinometer can also just test vertically which means one would have to switch the position of the test subject more in order to be able to test the subject.

A simple short armed goniometer from Kinetec was used for the measurements. At first a goniometer with longer arms were used, but the long armed goniometer was very stiff and could not be bent along the leg of the test subject. The long armed goniometer also just showed 180° which meant we had to start the measurement from 90° and count from there. When testing so many subjects the researchers needed to be sure about the measurements and be totally sure of the amount of degrees measured.

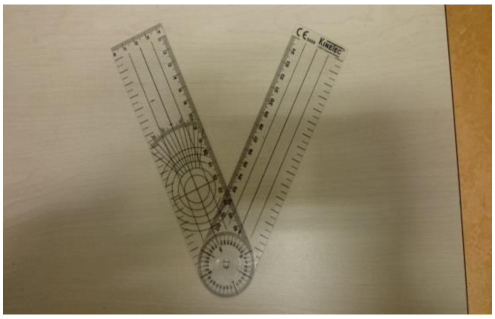

Figure 2
The goniometer used for testing.

All measurements were rounded down to 1 decimal with reading error of ± 0.5° for example: 45, 5° ± 0.5.

In a study done by Silvio Nussbaumer et al[13] that compared a goniometer with an electromagnetic tracking system it was concluded that goniometers showed intra-tester reliability with Intraclass correlation coefficients above 0.90 for all ROM assessments except for hip adduction (0.82-0.84). They also concluded that the goniometer would still be the first choice when assessing ROM for their clinic. The study also showed that testing passive hip joint angles with a goniometer was reliable from one day to another.

Research procedure

Participants were invited to join the clinical trial which took 10-15 minutes for each participant. The test subjects were put in a schedule and it was sent out to the test subjects in advance. The test subjects also received written and verbal information about the research and if the test subjects had further questions they were answered.

While doing measurements there were not placed any markers on the body in order to find the anatomical landmarks, they were palpated for each time. Visual approximation was used in order to find the midline of the thigh; the patella was used as a reference point.

When measuring abduction the fulcrum of the goniometer was placed on the anterior superior iliac spine and the arm of the goniometer was placed on the midline of the thigh with patella as reference point. During the measuring of adduction the fulcrum of the goniometer was placed on the ischial tuberosity and the arm of the goniometer was placed on the midline of the thigh with patella as reference point. For measuring internal rotation and external rotation the fulcrum of the goniometer was placed at the apex of the patella and the arm of the goniometer was placed along the tibia.

Since the body was placed in functional positions followed by a ROM measurement, two assessors were needed in order to perform the tasks in this procedure; one for positioning, the other for the ROM measurement. Each tester had the same function during the whole experimental procedure. Tester one held the test subject in the desired position and tester two did the measurement with the goniometer. The testing was the same for all subjects and the measurements were done in the same sequence (abduction, adduction, internal rotation and external rotation).

The ROM was measured once per position for each test subject, and the test subjects had no warming up beforehand. The end range was found when resistance was met at the end of the movement or the test subject experienced pain. The end range was expected to be a soft end feel.

The whole measurement protocol was repeated once for an at random selected test subject in each group the day after the original test in order to determine repeatability.

1. The test subjects were first measured in the standard position for assessing range of motion. The test subjects were put in a prone position and the hip was put in 0 degrees of flexion for testing abduction and adduction. For testing internal and external rotation the hip was put in 90 degrees of flexion.

2. Then test subjects were placed on the treatment bench lying in a supine position and abduction, adduction, internal rotation and external rotation were measured with the hip put in extension.

3. In the end the test subjects were placed on the treatment bench in side lying with the hip in maximal extension and the trunk in contralateral rotation and then abduction, adduction, internal rotation and external rotation were measured.

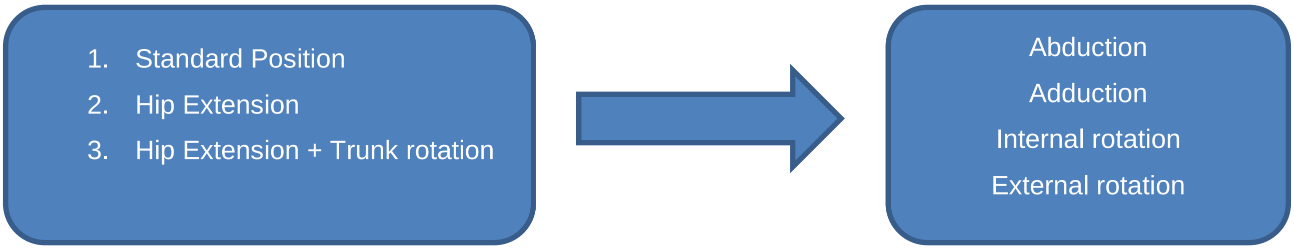

Figure 3.
Overview of the test protocol.

Figure 4.
Contralateral trunk rotation and hip extension position while measuring abduction.

Figure 5.
Contralateral trunk rotation and hip extension position while measuring adduction.

Figure 6.
The hip extension position while measuring internal rotation.

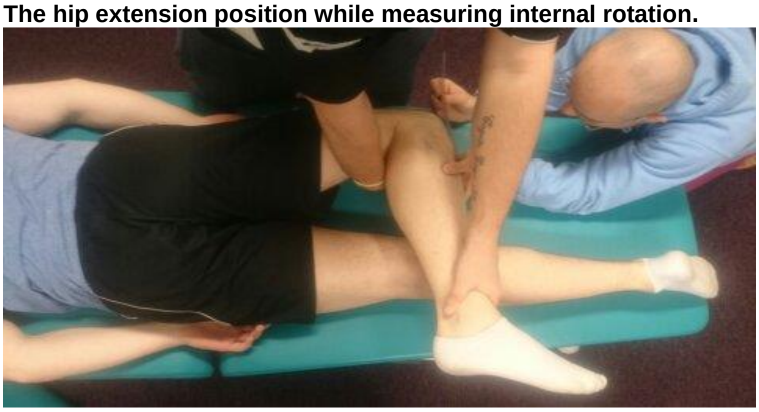

Figure 7.
The hip extension position while measuring external rotation.

Ethical aspects

This study was considered to be non- WMO obligated since none of the test subjects experienced harm or risk involved with being a part of this research project. The test subjects were sufficiently informed before testing procedure started and they had read an information letter and signed an informed consent **(see appendix I)**

Statistical analysis

The data of the groups were collected and compared to each other with the Independent t-test, using SPSS 2014.

Test – retest data was analyzed by using the Pearson Correlation test. One subject selected at random from each group was retested the day after the original test. Pearson correlation test was used because a small sample was needed in order to check correlation and to get an indication of the test protocol.

The non-football player's range of motion outcome was compared with the corresponding outcome of the football players and the standard way of measuring ROM was compared with the functional ROM. The data was put into SPSS and checked for correlation and normal distribution.

The following numerical and visual outputs were investigated:

1. The Skewness and kurtosis z-values, which should be somewhere in the span of -1.96 and +1.96, was checked by dividing skewness and kurtosis on their standard error.
2. The histograms, Normal Q-Q plots and Box plots, which should be able to visually give an indication of whether the data is approximately normally distributed.
3. The Shapiro-Wilk p-value, which should be above 0.05 in order to maintain the null hypothesis.

Results

In the study 30 subjects were included, 15 were categorized as non-football players and 15 were categorized as football players. ROM of abduction/adduction and Internal/external rotation was measured for both groups in three different positions. All the data was handled in SPSS.
The distribution of the data was tested with the Shapiro-Wilk test. The null hypothesis for the Shapiro-Wilk test is that the data is normally distributed, and this hypothesis is rejected if the p-value was below 0.05. In the table the significance (sig) is shown in the last column. The Shapiro-Wilk test result showed 2 out of 12 values below 0.05 and this means that the data was for the most part normally distributed and thus the researcher chose to use the Parametric Independent t-test.
(The results of the Shapiro-Wilk test can be seen in Appendix II)

Table 1: The difference in means of degrees between the two groups, the standard deviation and the significance of every movement direction that were measured.

	Measurement	Group	Mean	Std. Deviation	Sig
Standard position	Abduction	Non-football player	40.7	4.4	
		Football player	37.8	6.1	.146
	Adduction	Non-football player	17.2	4.9	
		Football player	14.6	4.5	.155
	Internal rotation	Non-football player	41.2	8.5	
		Football player	42.4	8.0	.679
	External rotation	Non-football player	55.2	11.3	
		Football player	51.6	9.5	.356
Position of Hip extension	Abduction + hip extension*	Non-football player	39.8	8.4	
		Football player	28.4	3.7	.000*
	Adduction + hip extension	Non-football player	12.1	3.4	
		Football player	12.6	4.4	.714
	Internal rotation + hip extension	Non-football player	51.5	8.2	
		Football player	50.9	7.6	.838
	External rotation + hip extension	Non-football player	67.4	8.5	
		Football player	64.2	8.6	.307
Position of Hip extension + trunk rotation	Abduction + trunk rotation	Non-football player	30.9	7.3	
		Football player	27.6	4.6	.157
	Adduction + trunk rotation	Non-football player	10.8	4.1	
		Football player	11.1	4.0	.860
	Internal rotation + trunk rotation	Non-football player	42.8	9.5	
		Football player	40.8	11.4	.619
	External rotation + trunk rotation	Non-football player	40.5	7.2	
		Football player	44.8	9.5	.173

Table 1 provides insight in the means of the non-football players versus the football player and the statistical significance of each result. Abduction with hip extension proved to be the only movement direction with a proven significant difference (Sig 0.000). The rest were all insignificant and were in the range of 0.179 to 0.952. This statistical significant result shows that the non-football players had almost 10° more ROM than the football players in the hip when measuring their abduction when their hip was put in extension. A better overview of the statistical significance of each measurement can be seen in tables which are presented in **appendix III & IV**

Table 2: The statistics from the Pearson correlation test from SPSS.

Group	Pearson correlation
Football players test - retest	**0.978**
Non-football players test - retest	**0.989**

The test – retest data got tested with Pearson correlation test.12 measurements from day 1 were compared to those of day 2, for one participant from each group. As can be seen in the table above correlation of test and retest for football players were 0.978 and non-football players was 0.989. For the full statistics **(See appendix V)**

Table 3: Extract of group means from table 1 that present the degrees of means for the measurements

Measurement for abduction	**Non-football players**	**Football players**
Standard position	40.7	37.8
Hip extension	39.8	28.4
Hip extension and trunk rotation	30.9	27.6
Measurements for adduction.	**Non-football players**	**Football players**
Standard Position	17.2	14.7
Hip extension	12.1	12.6
Hip extension and trunk rotation	10.9	11.1
Measurement for internal rotation	**Non-football players**	**Football players**
Standard position	41.2	42.4
Hip extension	51.5	50.9
Hip extension and trunk rotation	42.8	40.8
Measurement for external rotation	**Non-football players**	**Football players**
Standard position	55.3	51.7
Hip extension	67.4	64.2
Hip extension and trunk rotation	40.5	44.9

In table 3 one can observe a trend in the data analyzed when one looks at adduction and external rotation. It shows the ROM of the two groups through all 3 positions they got tested in. As can be seen in the table above in the standard position and external rotation the non-football players have 55.2 and the football players have 51.6. In the end position (hip extension and trunk rotation) the non-football players have 40.5 and the football players have 44.8.
For adduction in the standard position the non-football players have 17.2 while the football players have 14.6. In the end position the non-football players have 10.8 and the football players have 11.1.

Discussion

Interpretation of the experimental results

In this study it is attempted to find a more specific way of testing ROM in the athletic population and in this case soccer players. The primary aim of this study was to find the difference between non-football players and football players with regards to ROM and discover possible functional adaptations due to the many years of playing football.
There has been done very little research about this new concept that tests ROM in a sport specific position in this case related to the backswing in football. This means that ROM is being tested in a position that comes very natural to the injured athlete because of years of playing football.
Very little is known about measuring hip ROM in a sport specific position thus we cannot compare our outcomes with literature. There is a pilot study on this new concept by Igor Tak and Rob Langhout[11] of which, however, the data has not been published yet.

For this purpose the hip motions abduction, adduction, internal rotation and external rotation were measured in 3 different hip and trunk positions giving 12 results for both football players and non-football players. For only one situation, hip extension in combination with abduction there is a statistical difference. In all the other situations no differences were found. The reason for this is unknown seeing as the non-football players had 39.8 degrees on average and the football players had 28.4 degrees on average. The researcher cannot come to a possible explanation for this. If it was the other way around one could make the case for the football players presenting functional adaptations. This is because abduction and hip extension are crucial in the backswing and it therefore would make sense if the football players had more average ROM. The researchers propose to do the same study with larger groups of test subjects to get a clear view of the trends observed in table 3.
Pearson correlation test was used in order to assess the measurement protocol and the test – retest of 1 individual from each group the day after the original test yielded sufficient results 0.978 for football players and non-football players 0.989. This shows that the researchers were able to test a subject and re-test the same subject and get the same outcome.

In table 3 in the result section one can observe a trend in the data analyzed, one can observe that in the standard position the non-football players have on average more ROM (in 3 of 4 applied movements).
When the position is made even just a little bit more sport specific the ROM (hip in extension position) scores start to even out.
In the most sport specific position (hip in extension and trunk rotation) that mimics the backswing the soccer players have on average more ROM.
This gives reason to believe that this comes from the years of football playing and that functional adaptations have occurred and is of influence.

Another thing that can be observed from this table is the fact that abduction and adduction decreases the more sport specific the position got. When compared to external and internal rotation average

ROM only increased a lot in the hip extension position.

This study was not successful in proving that a more specific way of testing ROM is better based on the outcomes of this research study. One can speculate as to whether the level of the football players is of influence. The suggestion to solve this would be to do the same experiment with football players of a higher division with more play experience. The aim of this study is partly answered when looking at the ROM averages in table 3 of the result section. One can see there is a difference between the two groups, but one cannot come to a final conclusion about what the difference is because the differences are mostly not statistically significant. One can only observe a trend in the data which leads to the thought that the more football specific the position got the more the two groups evened out and in the final position the football players have on average more ROM in two out of four positions compared to the non-football players.

Table 5.
The results from our research project compared to that of values in literature with respect to the standard position of the hip

ROM	Abduction	Adduction	Internal rotation	External rotation
Non-football players	40.73°	17.20°	41.20°	55.27°
Football players	37.80°	14.67°	42.47°	51.67°
Values according to literature [14]	40°	25°	45°	45°

As one can observe in table 5, our ROM results regarding the hip in standard position were either under or over the value found in literature. There are a few possible sources of influence that may have occurred such as various compensations by a pelvic shift or a pelvic tilt. One could also keep in mind that no warming up was being done beforehand. This could make the test subjects more hesitant in allowing full stretch of the respective muscles that correlate with the movement directions being tested. One can also observe that the football players had lower ROM on average for all of the measurements except internal rotation.

Possible significance of the present results

In this study it is attempted to identify functional adaptations of the hip similar to that of the shoulder and the Glenohumeral Internal Rotation Deficit (GIRD) syndrome [15]. Gird is a normal phenomenon that is to be expected in throwing athletes. This syndrome occurs due to functional adaptation of the glenohumeral joint. If the athlete does not have a loss of internal rotation then the athlete will not have the requisite glenohumeral external rotation to make a baseball pitch reaching up to 100miles per hour or serve a tennis ball at velocities of 120 miles per hour or more.

In the hip there is a similar syndrome referred to as hip internal rotation deficit (HIRD) which is a

decreased hip internal rotation, it’s somewhat similar to that of GIRD syndrome [16]. HIRD occurs when the athlete tend to use more external rotation than internal rotation in their sport and this leads to less internal rotation and slight increase of external rotation.
HIRD has been linked with a variety of injuries in the athletic population the injuries include medial tibial stress syndrome, low back pain, groin injuries and shoulder injuries.
In order for the athlete to be able to sufficiently extend the hip towards the end of the gait cycle sufficient hip internal rotation is needed [17 - 18].
In fact without sufficient internal rotation of the hip the body creates different compensations which create problems by themselves and somewhere along the line these leads towards injury. The most common compensations to be seen in those with a HIRD are over pronation of the feet, a knee valgus and reduced step length, external rotation of the foot towards the terminal stance phase, increased lumbar and knee extension.
Hence, with such a varied compensation mechanism the result is a possibility of numerous injuries from the ankle all the way to the shoulder. A HIRD becomes a bigger problem in the sports or activities that require either deep hip flexion or rotation through the hip, pelvis, lumbar and thoracic spine. During the backswing in football the hip goes into extension and rotation, the lumbar and thoracic spine go through contralateral rotation. It is safe to say that football players are disposed to the stresses which can cause injury. A lot of research has been done over the last 30 years into increasing the knowledge of the relationship between reduced hip ROM and groin injury [19-20-21].
The research that has been done thus far have discovered that players with no history of groin complaints, but who displayed decreased hip ROM later went on to have a chronic groin injury.

Verrall GM et al.[22] did a study that proved a risk factor for a groin injury is decreased hip ROM and in particular decreased Hip internal rotation. The hypothesis their research had was that a decreased hip internal rotation puts more stress on the pelvic ring. This means during the athletes performance of twisting and turning motions there will be an increased risk of suffering a groin injury.

If the hypothesis of Verrall GM et al is correct; their hypothesis that a decreased hip ROM may lead to excessive stress on the pelvis is true then it is also possible that the knee has to compensate for the internal rotation deficit in the hip.
This in turn could result in the athlete having more internal rotation of the knee which again could predispose the athlete for other injuries. The increased internal rotation of the knee is a known risk factor for suffering ACL injuries.

So what can be seen? One can see similarities between GIRD and HIRD, but what clinical relevance does it have?

We can see similar syndromes in two completely different joints, but what is the difference between the two? If we take GIRD it is a functional adaptation that has to happen in order to create the power to pitch a baseball. If we then look closer at HIRD it is an adaptation which could have a huge negative impact on the athlete's performance. This is because the few degrees of external rotation the athlete get is not equal to the ROM deficit that occurs for internal rotation.

Possible uses of this sport specific position would be the increased knowledge about the athletes ROM in the position where the injury occurs most of the time. This may also result in specific treatment with mobilizations in the same position as the players were tested in. The testing in the sport specific position can be used for injured athletes, but it could also be used as a preventive measure/screening tool where the physiotherapist of the team/organization tests all the players during pre-season. This results in a bigger picture of which players are predisposed to injury through for example: a lack of internal rotation. The testing in itself took about 10min with 2 testers.
The practical consequence of needing 2 testers is that one needs to put more resources into it. One could try to do it with only one physiotherapist, but then an inclinometer is possibly a better option than the goniometer as it will be easier for the tester.
Two people are needed in order to insure better accuracy of the measurements. If one had a 3rd tester that could support the pelvis the testing time would decrease even more.
In order to test a football team of 30 players one would need 5 hours for testing in total if one spent approximately 10 minutes on each player. Then you have screened all your players and found which players are predisposed to injury. One can then intervene and give treatment based on the screening.

Study limitations and clinical implications

There were a few sources of possible errors during the measuring of the test subjects: the researchers did not place markings on the anatomical references that were used, thus leading to not being able to keep the stationary and moveable arm of the goniometer correctly aligned at all times. The researchers had big problems during the ROM testing in the standard position where trouble with the pelvis shifting occurred, thus creating compensatory movements. Even though this study showed good test –retest result it just means the researchers were accurate in their inaccuracy. What is meant by this is that the reproducibility by the researchers was deemed good, but the validity is deemed poor.

It could be that compensations were allowed to happen during the original test and the retest.
One should perhaps have had a 3rd tester that could fixate and double check whether the pelvis were shifting or tilting.
For the functional position the pelvis shift is necessary and creates the 3D position wanted for our study.
Other aspects that could play a part in the results were the test subject's inability to fully relax and the fact that no warming up beforehand was done with our test subjects.
The fact that no warming up was done could play a part in the outcomes, doing a warm up would ready the tissues for work and possibly influence the outcomes by having on average more ROM.
Therefore for the further research it is advised to create a standardized warm up protocol before the measurements take place, more accurate positioning of the goniometer by marking on the anatomical references and the examiners going through training with the goniometer beforehand so that they

have acquired more experience in the use of the tool. This has also been supported by other researchers who also recognize that training of examiners beforehand plays a vital part in concerning the ability to differentiate and determine the true ROM which sometimes can be difficult. [23 - 24]

There is also the question of whether the football players are of a high enough level to show the outcome predicted beforehand. What is meant by this is that football players on a higher level undergo a lot more training during the week which may accentuate the functional adaptations.

It is also known that football players on a higher level in general have a higher physical capacity and perhaps do more stretching than the amateur player does. This however is not clear evidence that the test subjects in this study is not of a high enough level, but one could say that the possibility is definitely present.

In this research study it was stated that participants for the football group had to have played a minimum of 5 years. Little is known about functional adaptations and what time span is needed in order to achieve these adaptations. As this research did not record any demographic data it makes it difficult to ascertain how many years of playing experience they have on average.

The football players that were tested can be considered recreational players since they don't live off playing football. The team they are a part of is playing in the 4th division in the Dutch league system. Therefore the outcome can become affected by this fact. This is also something to take into consideration for the future research.

From this research study one cannot prove that football players have any functional adaptations when compared to non-football players. Subsequently for the hip extension position in combination with abduction the study discovered that there was a statistical significance difference between the groups. The non-football players had 38.8 degrees on average while the football players had 28.4 degrees.

Therefore further research with larger groups of test subjects is warranted in the concept of ROM in sport specific position(s) in this case related to the backswing in football. And we also recommend the training of the testers beforehand so that they acquire necessary experience to make reliable measurements.

Conclusion

The findings of this research project showed that there was statistically significant difference between the two populations in the measurement of hip extension position in combination with abduction. For this measurement the non-football players had on average 10° more ROM than the football players. For all the other hip positions there were no statistical differences found.
The intra – tester reliability is considered good. It was checked with Pearson correlation test showing test – retest results of (P=) 0.978 for football players and (P=) 0.989 for non-football players.
However, in the results a trend was observed for adduction and external rotation, where in the standard position the non – football players had the most ROM, but once it got more sport specific the football players showed more ROM, but it was not considered as statistically significant.
It's recommended that for the future research tester training beforehand is undergone [16 – 17]
Based on the results of this study being limited one can conclude that further research is needed in the new concept of sport specific ROM and the testing or screening of this.

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Appendix I: Information letter and Informed consent.

Dear Participant:

My name is Kristian Hauan; I am a 4th year student at Fontys University of applied sciences in the physiotherapy department under the supervision of Ton de Lange. You are invited to participate in an experimental project entitled: « Testing hip ROM in functional positions of hip and trunk»
The purpose of this study is to check whether there is a difference in the hip ROM between three ways of collecting data, the standard way of testing range of motion and two more functional way of testing. The study has been approved by Fontys University.

In the following experiment you will be ask to lie on a physiotherapy bench. Your passive hip range of motion will be measured in three different trunk – hip position combinations of which one is mimicking the kicking position, For all three trunk – hip position combinations you will be placed by a physiotherapist student in each of these positions. Different directions will be measured and they will be measured by using a goniometer. This experiment will require maximum 20 minutes of your time.

There are no identified risks related to participating in this experiment. The experiment is confidential and anonymous. Participation in this research is completely voluntary and you may refuse at any time to participate or continue without consequence. The experiment will be just one session only. You will receive no compensation for participating in the research study (except eternal glory and gratitude)
The data of the experiment will only be reported in aggregated form to protect the identity of participant. Neither the researcher nor the University has a conflict of interest with the results.

Further information regarding the research can be obtained by contacting me, Kristian Hauan at k.hauan@student.fontys.nl

You need to be at least 16 years of age and not above 30 years, a male with no history of surgery or injury of the hip for the past 3 months.

In case of an injury or any unexpected event which might interfere with your participation, please contact one of the researchers via email.

Informed consent

Research Title« Testing hip ROM in functional positions of hip and trunk»
Researcher: Kristian Hauan

To be completed by the participant
I declare to be informed about the nature, method, purpose and risks and impact of the research on me. I am being informed that the data and results of the research will be anonymous and confidential. The data will not be used for any other purpose. In case of any questions the researchers will provide you with any further needed information.

I agree voluntarily to participate in this study. I behold myself at my rights to step out of the research at any moment without a reason.

Name of participant: ....

Date:............... Signature Participant:………………………………………………..

To be completed by the executive researcher
I have given an oral and written explanation of the study. I will answer remaining questions about the research. In case of withdrawal of the participant out of the experiment, there will be no consequence for him.

Researchers Name:
………………………………………………………………………………..…………..

Date... Signature researcher

Appendix II: Results of the Shapiro-Wilk test.

*The results marked in yellow are the results with p-value under 0.05.

Tests of Normality

	group	Shapiro-Wilk	
		df	Sig.
Abduction	Non-football player	15	.307
	Football player	15	.096
Adduction	Non-football player	15	.318
	Football player	15	.687
Internal_rotation	Non-football player	15	.590
	Football player	15	.926
External_rotation	Non-football player	15	.072
	Football player	15	.483
Abduction_extension	Non-football player	15	.178
	Football player	15	.054
Adduction_extension	Non-football player	15	.006
	Football player	15	.094
Internal_rotation_extension	Non-football player	15	.771
	Football player	15	.183
External_rotation_extension	Non-football player	15	.056
	Football player	15	.167
Abduction_trunkrotation	Non-football player	15	.052
	Football player	15	.175
Adduction_trunkrotation	Non-football player	15	.007
	Football player	15	.014
External_rotation_trunkrotation	Non-football player	15	.473
	Football player	15	.576
Internal_rotation_trunkrotation	Non-football player	15	.101
	Football player	15	.928

a. Lilliefors Significance Correction

*. This is a lower bound of the true significance

Appendix III: Group statistics.

This table (appendix IV) and the following table (appendix V) were compressed into one table that presents the means, the standard error and the significance of each result.

Group Statistics

	group	N	Mean	Std. Deviation	Std. Error Mean
Abduction	Non-footballplayer	15	40.73	4.496	1.161
	Footballplayer	15	37.80	6.120	1.580
Adduction	Non-footballplayer	15	17.20	4.931	1.273
	Footballplayer	15	14.67	4.562	1.178
Internal_rotation	Non-footballplayer	15	41.20	8.596	2.219
	Footballplayer	15	42.47	8.008	2.068
External_rotation	Non-footballplayer	15	55.27	11.392	2.941
	Footballplayer	15	51.67	9.552	2.466
Abduction_extension	Non-footballplayer	15	39.80	8.428	2.176
	Footballplayer	15	28.47	3.796	.980
Adduction_extension	Non-footballplayer	15	12.13	3.420	.883
	Footballplayer	15	12.67	4.402	1.137
Internal_rotation_extension	Non-footballplayer	15	51.53	8.288	2.140
	Footballplayer	15	50.93	7.620	1.968
External_rotation_extension	Non-footballplayer	15	67.47	8.551	2.208
	Footballplayer	15	64.20	8.645	2.232
Abduction_trunkrotation	Non-footballplayer	15	30.93	7.363	1.901
	Footballplayer	15	27.67	4.639	1.198
Adduction_trunkrotation	Non-footballplayer	15	10.87	4.190	1.082
	Footballplayer	15	11.13	4.033	1.041
Internal_rotation_trunkrotation	Non-footballplayer	15	42.80	9.541	2.463
	Footballplayer	15	40.87	11.438	2.953
External_rotation_trunkrotation	Non-footballplayer	15	40.53	7.230	1.867
	Footballplayer	15	44.87	9.591	2.476

Appendix IV: Independent samples test.

This table presents the results for the independent samples test and the significance of each result.

From this table the sig (2-tailed) column was put together with the table in Appendix III and presented in the result section.

Independent Samples Test		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	t	df	Sig. (2-tailed)
Abduction	Equal variances assumed	1.622	.213	1.496	28	.146
	Equal variances not assumed			1.496	25.701	.147
Adduction	Equal variances assumed	.004	.948	1.461	28	.155
	Equal variances not assumed			1.461	27.832	.155
Internal rotation	Equal variances assumed	.032	.860	-.418	28	.679
	Equal variances not assumed			-.418	27.861	.679
External rotation	Equal variances assumed	.153	.699	.938	28	.356
	Equal variances not assumed			.938	27.174	.357
Abduction extension**	Equal variances assumed	7.407	.011	4.749	28	.000*
	Equal variances not assumed			4.749	19.456	.000*

Adductionextension	Equal variances assumed	1.896	.179	-.371	28	.714
	Equal variances not assumed			-.371	26.386	.714
Internal rotation extension	Equal variances assumed	.004	.952	.206	28	.838
	Equal variances not assumed			.206	27.805	.838
External rotation extension	Equal variances assumed	.267	.609	1.040	28	.307
	Equal variances not assumed			1.040	27.997	.307
Abduction trunkrotation	Equal variances assumed	1.395	.248	1.454	28	.157
	Equal variances not assumed			1.454	23.603	.159
Adduction trunkrotation	Equal variances assumed	.052	.822	-.178	28	.860
	Equal variances not assumed			-.178	27.960	.860
Internal rotation trunkrotation	Equal variances assumed	.723	.402	.503	28	.619
	Equal variances not assumed			.503	27.127	.619
External rotation trunkrotation	Equal variances assumed	1.580	.219	-1.397	28	.173
	Equal variances not assumed			-1.397	26.027	.174

Appendix V: Pearson correlation test.

Correlations

		Non_football_player_original	Non_football_player_retest	Football_player_original	Football_player_retest
Non_football_player_original	Pearson Correlation	1	.989**	.827**	.844**
	Sig. (2-tailed)		.000	.001	.001
	Sum of Squares and Cross-products	3754.250	3975.250	2660.500	3013.750
	Covariance	341.295	361.386	241.864	273.977
	N	12	12	12	12
Non_football_player_retest	Pearson Correlation	.989**	1	.835**	.849**
	Sig. (2-tailed)	.000		.001	.000
	Sum of Squares and Cross-products	3975.250	4304.917	2877.167	3246.417
	Covariance	361.386	391.356	261.561	295.129
	N	12	12	12	12
Football_player_original	Pearson Correlation	.827**	.835**	1	.976**
	Sig. (2-tailed)	.001	.001		.000
	Sum of Squares and Cross-products	2660.500	2877.167	2755.667	2986.167
	Covariance	241.864	261.561	250.515	271.470
	N	12	12	12	12
Football_player_retest	Pearson Correlation	.844**	.849**	.976**	1
	Sig. (2-tailed)	.001	.000	.000	
	Sum of Squares and Cross-products	3013.750	3246.417	2986.167	3398.917
	Covariance	273.977	295.129	271.470	308.992
	N	12	12	12	12

**. Correlation is significant at the 0.01 level (2-tailed).