



Original research

Do hip and groin muscle strength and symptoms change throughout a football season in professional male football players? A prospective cohort study with repeated measures



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ABSTRACT

Objectives: Groin injuries are common in professional male football and result in significant complaints, time-loss and cost. We aimed to study: 1. Normal values of hip muscle strength and self-reported hip and groin function (Hip And Groin Outcome Score (HAGOS)). 2. Changes in these values throughout the season. 3. If previous (groin) injuries, leg dominance or league were associated with these outcome measures.

Design: Prospective cohort study.

Methods: 313 professional male football players (11 clubs) participated. Player characteristics and previous injuries were registered. Hip muscle strength (hand-held dynamometer) and HAGOS measurements were done at the start, middle and end of the season.

Results: Data from 217 players were analysed. Adduction strength (mean \pm standard deviation, Nm/Kg) was 3.40 ± 0.72 (start), 3.30 ± 0.65 (mid) and 3.39 ± 0.74 (end) ($p = 0.186$). Abduction strength was 3.45 ± 0.67 , 3.14 ± 0.57 and 3.28 ± 0.61 ($p < 0.001$). Adduction/abduction ratio was 1.00 ± 0.21 , 1.07 ± 0.22 and 1.05 ± 0.23 ($p < 0.001$). Statistically, the HAGOS-subscale 'Pain' (median [interquartile range]) deteriorated slightly during the season ($p = 0.005$), especially from mid-season (97.5 [90.6–100.0]) to end-of-season (95.0 [87.5–100.0]) ($p = 0.003$). Other subscale scores remained unchanged between time points: 85.7 (symptoms), 100.0 (daily living), 96.9 (sports and recreation) 100.0, (physical activities) and 90.0 (quality of life). Previous injuries were associated with lower HAGOS-scores. Dominant legs had higher abduction strength ($p < 0.001$) and lower adduction/abduction ratio ($p < 0.001$). No differences between leagues were found for hip muscle strength and HAGOS-scores.

Conclusions: In Dutch male professional football players, hip muscle strength and HAGOS-scores remained relatively stable throughout the season. Pain increased slightly, which while statistically significant, was not clinically relevant.

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Practical implications

- Normal values for hip abduction, adduction strength and ratio, plus HAGOS-scores were found to be stable over the course of a full football season in Dutch professional male football players.

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- A slight increase in the HAGOS pain subscale towards the end of season may be expected in this population, and was deemed clinically irrelevant.
- Changes in these scores throughout the season should therefore be considered a signal for staff attention, providing potential for implementing secondary prevention measures.
- Players with previous injury and (multiple) previous groin injury experience a higher level of hip and groin related problems. Implementing primary prevention measures, such as adduction strengthening, and closely monitoring these players throughout the season will likely assist in preventing groin problems in these players.

1. Introduction

Groin injuries are common in athletes,^{1,2} especially in professional male football, where they account for around 10% of all injuries.² Groin injury incidence ranges from 0.2 to 2.1 per 1000 h of football and groin injuries affect 20% of all players each season.^{2–4} Groin injuries result in significant time-loss from training and/or match play, typically between 15 and 20 days^{2,5,6} and 28 days for recurrent injuries.⁷

Although groin pain forces some players to stop playing, many continue to play with pain.⁸ This is referred to as non-time-loss groin injury, which is also relevant as the pain may interfere with performance levels.⁹ Preventing the progression of non-time-loss injuries to time-loss injury and the accompanying reduction of athlete performance levels is important from both individual and clubs' perspective. Monitoring of hip and groin functioning with patient-reported outcome measures and strength and pain provocation testing throughout the football season may assist in detecting early signs of groin pain.^{10,11}

Hip muscle strength assessments may assist in clinical examination, injury prevention and to tailor management strategies.¹² Hip adduction strength was found to be reduced preceding and during the onset of groin pain in athletes¹³ and lower adduction strength is associated with an increased risk of groin injury.^{14,15} Eccentric adduction strength (Nm/kg) is reported to be between 2.45 and 2.99 for the dominant leg and 2.35–2.98 for the non-dominant leg in male football players in Denmark^{16,17} and Qatar.¹⁸ Eccentric abduction strength (Nm/kg) ranges from 2.35 to 2.59 for the dominant leg and from 2.25 to 2.56 for the non-dominant leg.^{16–18} However, we currently do not know if and how these measures vary over the course of the season.

Injuries from a previous season, even those from a region other than the groin, can increase the risk of a new groin injury in the next season.^{5,19} Previous groin injury, higher level of play and lower level of sport-specific training are associated with an increased risk of groin injury in athletes.¹⁵ To the best of our knowledge, no studies have prospectively reported repetitive measurements of hip muscle strength and hip and groin functioning during a full season in professional adult football players. These values can assist clinical assessment and targeted management strategies of professional football players during the (pre)season. The aims of this study were: (1) to assess normal values of hip muscle strength and self-reported hip and groin functioning in professional football players, (2) to observe if those scores change throughout the season and (3) explore whether previous (groin) injuries, leg dominance and league were associated with hip muscle strength and hip and groin functioning during the full football season.

2. Materials and methods

A prospective cohort study, with information available on previous groin injuries and injuries other than the groin. The study

protocol was approved by the Medical Ethical Committee of Amsterdam University Medical Center (W15.086#15.0100). After the football clubs were invited and agreed to participate, their medical staff invited the individual players, who each gave their written informed consent prior to participation.

The GRoin Injury Prevention (GRIP) study invited 16 Dutch football clubs from the first and second professional league to participate. This prospective study was part of a large-scale study on groin injuries and was funded by the Taskforce for Applied Research (SIA, reference number 2014-01-15M).¹⁹ The eligibility criteria for inclusion were, aged 18 years or older, playing in the first squad of the club, able to follow Dutch or English instructions, understand the participant information folder and capable of undergoing hip muscle strength testing (e.g. not sick/currently injured). Three different data collection time points were planned; pre-season (June–July 2015); mid-season (October–November 2015) and end-of-season (March 2016). All measurements were performed at the participating club.

Participant characteristics (age, height, weight, body mass index (BMI) and leg dominance) were recorded with a standardised questionnaire at each time point.

Physical examination was performed according the protocol of Mosler *et al.*¹⁸ Six physiotherapists with 5–31 years of clinical experience were trained for 9 h for the purposes of this study, prior to the inclusion procedure. None of them was affiliated to any of the participating clubs. Leg length was calculated by using the height/leg length ratio calculated from the measures taken in the study of Mosler *et al.*,¹⁸ resulting in a persons' height multiplied by 0.4867.

Hip adduction and abduction strength was tested at all three time points during the season by the research team of physiotherapists using a hand-held dynamometer (MicroFET 2, Hoggan Scientific LLC, Salt Lake City, UT, USA). The participants were positioned on a physio bench in a standardised side lying position. For adduction, the participant lay on the side of the leg to be tested, with the knee in full extension. The contralateral hip and knee were in 90 degrees of flexion, while the knee was supported by a firm roll (Enraf Nonius, Delft, the Netherlands) to maintain neutral pelvic position.¹⁸ For abduction, the participant lay on the non-tested side, with the hip and knee of the non-tested leg in 90 degrees of flexion. The hip of the leg to be tested was in neutral flexion/extension with the knee in full extension. For both tests, standardised instructions were used to get to maximal isometric contraction in 3 s, followed by the 2-second eccentric break test. Intrarater and interrater intraclass correlation coefficients have been presented previously.¹⁹

The Hip And Groin Outcome Score (HAGOS) was used to quantify the current level of hip and groin problems. It is reliable and valid for this purpose in young to middle-aged active individuals and available in Dutch.^{1,20,21} Information is obtained on 6 different subscales. Answers are recorded using a 5-point Likert scale and the subscale scores are then normalised between 0 and 100, with 100 indicating no hip or groin related problems. Participants completed HAGOS at the testing day prior to physical examination at each of the three time points in the season (early, mid, end). The Dutch version of HAGOS was filled in online (Questback digital platform; Questback, Oslo, Norway), and foreign players filled in an English version on paper.

Self-reported history (any moment in the past) of groin injuries based on time-loss, was recorded in 3 categories:

- 1 No time-loss groin injury
- 2 1 previous time-loss groin injury
- 3 More than 1 previous time-loss groin injury

Time-loss injury was defined as a player being unable to fully take part in at least 1 football training and/or match.²² Previous injury other than the groin was defined as time-loss due to injury

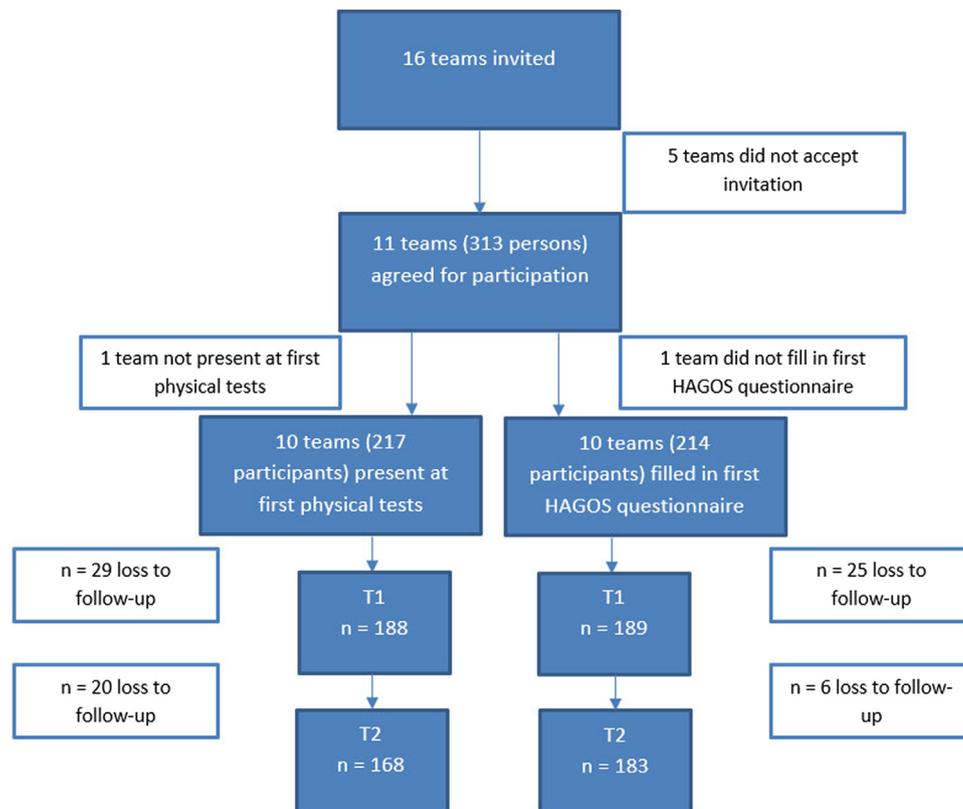


Fig. 1. Flowchart of inclusions and participants at different time points.

Note: T1 is the mid-season time point, T2 is the end-of-season time point.

of any other region of the body in the previous (2014–2015) season. Body location and duration of time-loss for these injuries were recorded. Time-loss was defined from the day of the injury to the day being able to take part in full training or match play again.²³

Descriptive analyses were conducted for baseline participant characteristics. All strength assessments were tested for normality (Shapiro–Wilk test). Normally distributed data are presented as mean and standard deviation and when not normally distributed as median and Inter Quartile Range (IQR), 25th–75th percentile. The adduction/abduction ratio was calculated (peak adduction strength/peak abduction strength). Whether or not hip muscle strength and symptoms varied during one season was tested using a linear mixed model analysis. Hip muscle strength and HAGOS-scores were analysed at all time points as dependent variables over multiple time points. Post-hoc analysis was performed by pairwise comparison per time point with Bonferroni adjustments for multiple comparisons. Other variables such as previous (groin) injuries, leg dominance and league were entered as independent factors to analyse if they were associated with hip muscle strength or HAGOS-scores. Age and BMI were added in the model as covariates. Baseline characteristics of participants and drop-outs were compared using independent sample T-tests. Side was entered as repeated measure to account for interdependency between left and right legs. HAGOS-scores were analysed as continuous variables. All statistical analyses were performed using SPSS (IBM, Armonk, USA), version.²⁴

3. Results

Invitations were sent to 16 Dutch professional football clubs. In total, 11 teams took part representing 313 football players who filled in the standardised questionnaire. Baseline strength tests were completed by 217 players from 10 teams. Of these, 188 football players from 9 teams participated ($n=29$ [13%] loss to

follow-up) at mid-season strength tests and 168 football players of 9 teams at end-of-season tests ($n=49$ [23%] loss to follow-up). The first HAGOS-questionnaire was completed by 214 players from 10 teams, by 189 football players from 9 teams at mid-season ($n=25$ [12%] loss to follow-up) and by 183 football players from 9 teams at end-of-season ($n=31$ [14%] loss to follow-up) (Fig. 1). A statistical analysis revealed that drop-outs were 1.5 year older and had been playing for slightly longer than the actual study participants (Supplemental Table 1). Of the 11 teams at baseline, 9 participated in the highest league ('Eredivisie') and 2 in the second ('Jupiler League'). The average mean age was 23 years (range 17–37 years) for those who participated in the first strength tests (Table 1).

Mean values for hip muscle strength (adduction, abduction and adduction/abduction ratio) for dominant and non-dominant legs are presented (Table 2). Adduction strength (in Nm/Kg) did not change during the season (3.40 ± 0.72 , 3.30 ± 0.65 and 3.39 ± 0.74 , $p=0.186$). Abduction strength significantly decreased during the season from 3.45 ± 0.67 to 3.28 ± 0.61 Nm/Kg ($p < 0.001$), especially between baseline and mid-season (Δ mean = -0.31 , $p < 0.001$). The adduction/abduction ratio increased from 1.00 ± 0.21 to 1.05 ± 0.23 ($p < 0.001$), especially between baseline and mid-season (Δ mean = 0.07 , $p < 0.001$).

All HAGOS-scores were non-normally distributed at all time points. The median and IQRs of all 6 HAGOS-subcales are presented (Table 3). Only the subscale 'Pain' significantly decreased during the season ($p = 0.005$), especially from mid-season to end-of-season (Δ median = 2.5 , $p = 0.003$).

Hip abduction muscle strength was significantly higher ($\Delta = 0.11$, $p < 0.001$) and the adduction/abduction ratio therefore lower on the dominant leg side ($\Delta = 0.04$, $p < 0.001$) (Table 4). Players from the highest league were not significantly stronger (either towards adduction or abduction) nor had they different adduction/abduction ratios. Their HAGOS-scores did not differ from those of the lower league players (Table 1).

Table 1
Participant baseline characteristics (n = 217).

Characteristic	Value
Age, y	23.0 ± 3.8
Height, cm	183 ± 7
Weight, kg	78 ± 7
BMI, kg/m ^{2a}	23.4 ± 1.5
Years of professional football experience, y	4.8 ± 3.5 (n = 187)
Leg dominance, n (%)	
- Left	46 (21%)
- Right	158 (73%)
- Both	13 (6%)
Position in the field, n (%)	n = 216 ^b
- Goalkeeper	24 (11%)
- Defender	66 (31%)
- Midfielder	59 (27%)
- Attacker	67 (31%)
League, n (%)	
- Premier League ('Eredivisie')	155 (71%)
- First division ('Jupiler League')	62 (29%)
Previous groin injury, n (%)	n = 214 ^b
- No	136 (63%)
- Yes	78 (37%)
• Once	- 47 (22%)
• Multiple times	- 31 (15%)
Previous injury other than the groin, n (%)	n = 215 ^b
- No	114 (53%)
- Yes	101 (47%)

Data presented as mean ± standard deviation.

^a BMI: body mass index.

^b Lower numbers are presented due to missing player data.

Previous groin injuries were not associated with hip muscle strength measurement outcomes (Table 4). Both one and multiple previous groin injuries were associated with lower HAGOS-scores.

Table 2
Hip muscle strength of football players who attended at all time points during 1 football season (n = hips).

Hip muscle strength (Nm ^a /kg ^b)	Time points				P-value	Normal value ranges baseline				
	Baseline (n = 433)	Mid-season (n = 374)	End-of-season (n = 331)	Season difference		Very low (<2SD ^c)	Low (1–2SD ^c)	Normal	High (1–2SD ^c)	Very high (>2SD ^c)
Adduction	3.40 ± 0.72	3.30 ± 0.65	3.39 ± 0.74	-0.01	0.186	<2.0	2.0–2.7	2.7–4.1	4.1–4.8	>4.8
- Dominant	3.39 ± 0.73	3.31 ± 0.67	3.35 ± 0.74	-0.04						
- Non-dominant	3.41 ± 0.71	3.30 ± 0.63	3.43 ± 0.75	+0.02						
Abduction	3.45 ± 0.67	3.14 ± 0.57	3.28 ± 0.61	-0.17	<0.001	<2.1	2.1–2.8	2.8–4.1	4.1–4.8	>4.8
- Dominant	3.48 ± 0.68	3.19 ± 0.56	3.36 ± 0.60	-0.12						
- Non-dominant	3.42 ± 0.66	3.08 ± 0.59	3.20 ± 0.61	-0.22						
Adduction/abduction ratio	1.00 ± 0.21	1.07 ± 0.22	1.05 ± 0.23	+0.05	<0.001	<0.6	0.6–0.8	0.8–1.2	1.2–1.4	>1.4
- Dominant	0.99 ± 0.20	1.05 ± 0.21	1.01 ± 0.21	+0.02						
- Non-dominant	1.02 ± 0.21	1.09 ± 0.23	1.09 ± 0.25	+0.07						

Values are presented as mean ± SD. The absolute values of hip muscle strength are presented. P-values are based on estimated means.

^a Nm: newton per meter.

^b kg: kilogram.

^c SD: standard deviation.

Table 3
Hip and groin outcome scores over one football season.

HAGOS-subscores	Baseline (n = 214)	Mid-season (n = 189)	End-of-season (n = 183)	Overall effect*	Baseline to mid-season*	Mid-season to end-of-season*	Baseline to end-of-season*
Pain	95.0 (90.0–100.0)	97.5 (90.6–100.0)	95.0 (87.5–100.0)	0.005	0.643	0.003	0.063
Symptoms	85.7 (75.0–92.9)	85.7 (78.6–92.9)	85.7 (75.0–92.9)	0.365	0.696	0.725	1.000
Function in daily living	100.0 (95.0–100.0)	100.0 (95.0–100.0)	100.0 (95.0–100.0)	0.068	1.000	0.074	0.190
Function in sports and recreational activities	96.9 (90.6–100.0)	96.9 (90.6–100.0)	96.9 (87.5–100.0)	0.084	1.000	0.221	0.099
Participation in physical activities	100.0 (87.5–100.0)	100.0 (87.5–100.0)	100.0 (87.5–100.0)	0.219	0.572	1.000	0.345
Hip- and/or groin related quality of life	90.0 (75.0–100.0)	90.0 (80.0–100.0)	90.0 (75.0–100.0)	0.384	1.000	0.509	1.000

Values are expressed as median (IQR, 25th–75th centile).

* P-values are presented.

The differences for 'no previous groin injury' versus 'one previous groin injury' and versus 'more than one previous groin injury' were respectively 'Pain' (Δmedian = 2.5 and 7.5, **p = 0.001**), 'Symptoms' (Δmedian = 3.6 and 14.3, **p < 0.001**), 'Function in sports and recreational activities' (Δmedian = 0.0 and 9.4, **p < 0.001**), 'Participation in physical activities' (Δmedian = 0.0 and 12.5, **p = 0.015**) and 'Hip- and/or groin related quality of life' (Δmedian = 10.0 and 20.0, **p < 0.001**).

Previous injury other than the groin was not associated with lower hip muscle strength, though significantly associated with lower HAGOS-scores for the domains 'Pain' (Δmedian = 2.5, **p = 0.002**), 'Symptoms' (Δmedian = 7.2, **p = 0.003**), 'Function in daily living' (Δmedian = 0.0, **p = 0.031**), 'Function in sports and recreational activities' (Δmedian = 3.1, **p = 0.011**) and 'Hip- and/or groin related quality of life' (Δmedian = 10.0, **p = 0.007**).

4. Discussion

In this prospective cohort study of professional Dutch male football players, we repeatedly assessed profiles of hip muscle strength and symptoms throughout one full season. Hip muscle strength measures remained stable. Self-reported hip and groin pain slightly increased, however this statistical difference was deemed clinically irrelevant, as the minimal important change threshold was not exceeded.^{20,21} The significantly higher hip abduction strength found in dominant legs compared with non-dominant sides was within the range of standard error of measurement.¹⁶ Participants with previous groin injuries or injuries other than the groin had lower HAGOS-scores.

Adduction strength scores remained stable (3.4 ± 0.7 Nm/kg) throughout the season. Although hip abduction strength decreased

Table 4
Associations of independent variables with dependent variables during a full football season.

	Previous injury other than the groin			Previous groin injury				Dominant leg			League			
	No	Yes	P	No	Once	>1 time	P	No	Yes	P	1st	2nd	P	
Hip muscle strength*														
Abduction	3.31 ± 0.63	3.30 ± 0.63	0.975	3.28 ± 0.66	3.37 ± 0.57	3.31 ± 0.63	0.272	3.24 ± 0.64	3.35 ± 0.63	<0.001	3.31 ± 0.64	3.27 ± 0.62	0.691	
Adduction	3.41 ± 0.70	3.31 ± 0.72	0.437	3.36 ± 0.72	3.38 ± 0.68	3.33 ± 0.72	0.458	3.38 ± 0.70	3.35 ± 0.71	0.118	3.35 ± 0.70	3.41 ± 0.72	0.534	
Adduction-abduction ratio	1.05 ± 0.22	1.02 ± 0.22	0.404	1.04 ± 0.22	1.02 ± 0.24	1.02 ± 0.21	0.884	1.06 ± 0.23	1.02 ± 0.21	<0.001	1.03 ± 0.23	1.06 ± 0.21	0.236	
HAGOS ^a -subscales**														
Pain	97.5 (92.5–100.0)	95.0 (85.0–100.0)	0.002	97.5 (92.5–100.0)	95.0 (88.8–100.0)	90.0 (82.5–97.5)	0.001	N/A ^{b,c}			96.3 (90.0–100.0)	95.0 (90.0–100.0)	0.807	
Symptoms	89.3 (78.6–92.9)	82.1 (71.4–92.9)	0.003	89.3 (78.6–92.9)	85.71 (71.4–92.9)	75.0 (60.7–85.7)	<0.001	N/A ^{b,c}			85.7 (75.0–92.9)	85.7 (78.6–92.9)	0.726	
Function in daily living	100.0 (95.0–100.0)	100.0 (95.0–100.0)	0.031	100.0 (95.0–100.0)	100.0 (95.0–100.0)	100.0 (90.0–100.0)	0.267	N/A ^{b,c}			100.0 (95.0–100.0)	100.0 (95.0–100.0)	0.294	
Function in sports and recreational activities	100.0 (93.8–100.0)	96.89 (87.5–100.0)	0.011	100.0 (93.8–100.0)	100.0 (87.5–100.0)	90.6 (68.8–96.9)	<0.001	N/A ^{b,c}			96.9 (90.6–100.0)	96.9 (90.6–100.0)	0.729	
Participation in physical activities	100.0 (87.5–100.0)	100.0 (87.5–100.0)	0.407	100.0 (87.5–100.0)	100.0 (75.0–100.0)	87.5 (62.5–100.0)	0.015	N/A ^{b,c}			100.0 (87.5–100.0)	100.0 (87.5–100.0)	0.483	
Hip- and/or groin related quality of life	95.0 (80.0–100.0)	85.0 (70.0–100.0)	0.007	95.0 (82.5–100.0)	85.0 (75.0–100.0)	75.0 (55.0–85.0)	<0.001	N/A ^{b,c}			90.0 (75.0–100.0)	90.0 (75.0–100.0)	0.609	

^a HAGOS: Hip And Groin Outcome Score.

^b N/A: not applicable.

^c No statistical associations were performed due to the fact that HAGOS is a per person score and dominance per side measurement.

* Values are expressed as mean ± standard deviation and all P-values were corrected for age and BMI. Bolded P-values indicate a statistically significant difference.

** Values are expressed as median (IQR, 25th–75th percentile) and all P-values were corrected for age and BMI. Bolded P-values indicate a statistically significant difference.

from 3.45 ± 0.67 to 3.28 ± 0.61 Nm/kg, which reached the statistically significance threshold, this was consistently within the normal range for this population (<1 SD from the mean). Additionally, changes were not larger than the previously reported standard error of measurement for this assessment,¹⁶ thus confirming the stability of strength measures throughout the season. Previous studies have reported normal values for hip muscle strength in equivalent populations. In a cohort of 394 professional male football players from the Qatar Stars League,¹⁸ adduction strength was 3.0 ± 0.6 Nm/kg and abduction 2.6 ± 0.4 Nm/kg. In our current study we observed higher values of hip adduction and abduction strength, which may be explained by various training components such as: higher training and match play skill level, greater hours of intensive training on the field, additional strength training, greater overall training load, and biological differences relating to ethnicity may also play a role. These possible differences should be considered in future studies and in the application of these normal values to clinical practice. The slightly higher hip abduction strength observed on the dominant side did not exceed the standard error of measurement, and were within the normal range (<1 SD from the mean) at all time points.¹⁶ This concurs with the findings of the above mentioned Qatar cohort¹⁸ that dominance had minimal effect on adduction or abduction strength.

We observed an adduction/abduction ratio of 1.00 ± 0.21 , which increased during the season to 1.05 ± 0.23 ($p < 0.001$). This increase was explained by the decrease in abduction strength in combination with stable adduction strength. Different adduction/abduction ratios have previously been reported. Mosler et al.²⁰ reported this ratio to be 1.2 ± 0.3 in professional male football players in Qatar, slightly higher than that of Dutch professional male field hockey players²⁵ (1.09 ± 0.1) and American professional male ice-hockey players (0.95).²⁴ Therefore, these ratios appear to be population-specific. The clinical relevance of the observed significant increase of the adduction/abduction ratio in our study should be questioned, as it was within the normal (1 SD from the mean) range both between single time points as well as from the start to the end of the season.

When hip abduction is relatively high compared to adduction strength (thus a lower adduction/abduction ratio), one might be more prone to injury.²⁴ Strength imbalances (agonist vs antagonist) have been widely suggested to be a component of the muscle strain pathomechanism, for other anatomical regions.²⁶ It should be taken into account that differences in ratios seem to be population-specific, and various factors (training context, ethnicity) may influence in the expected strength outcomes.

We found that only the HAGOS 'Pain' scores slightly varied throughout the season. Players experienced significantly higher levels of pain at the beginning of the season, which then became lower at mid-season and again higher towards the end of the season (Δ median = 2.5). These differences might be explained by the lower fitness level at the start of the season and fatigue experienced towards the end-of-the-season. The clinical relevance of this change is limited though, as it was within the normal (IQR 25–75%) range in this cohort and did not exceed the smallest detectable change threshold.^{20,21} All other HAGOS-scores remained similar throughout the season. Wollin et al.¹¹ likewise found lower HAGOS-scores at the start of the season in a cohort of young (15 year old) football players, which improved during the season. They did not notice any deterioration in pain scores towards the end-of-season, which may be due to these players performing additional strength exercises and a specific groin injury prevention program. In semi-professional Norwegian male footballers, Harøy et al.²⁷ found that a specific adductor-strengthening program was beneficial in lowering self-reported levels of hip and groin problems. In our study, clubs did not report which football players performed adductor

strengthening in their training schedule, which may have confounded our results.

Recently Bourne et al.²⁸ reported that higher HAGOS-scores and higher levels of isometric hip abduction and adduction strength reduced the likelihood of future hip and groin injury in professional football players. These strength values cannot be compared with ours, as they did not correct for body weight and measured isometric rather than eccentric strength. Generalizability of their findings seems problematic as they used a specific testing device, which is not globally available. In Gaelic football²⁹ a higher risk of groin injuries (odds ratio = 8.94) was observed when pre-season HAGOS-subscales 'Function, sports and recreation' were lower than 87.5 points. These findings indicate the importance of monitoring hip and groin symptoms throughout the season. Our data reported relatively consistent HAGOS-scores with repeated measures taken throughout the season, and these can now serve as a reference value framework for clinicians working with professional male football teams.

We found that previous injury other than the groin (47%) and groin injury (37%: one injury = 22%, more than one injury = 15%) were not associated with hip muscle strength but were related to lower HAGOS-scores. This concurs with results from the previous study of this cohort which demonstrated that a general long-standing injury increased the risk of groin injury in the next season (hazard ratio: 5.1, 95% CI: 1.8, 14.5, $p = 0.003$).¹⁹ In general, professional male football players may experience some levels of hip and groin problems in the pre-season³⁰ and on continuing to play from mid-season to end-of-season as demonstrated in this current study. HAGOS-scores were found lowest in those with multiple previous groin injuries. The median scores for the Symptoms, Pain, Sports and Recreation and Physical Activities subscales were all equal to or lower than the lower bound of the IQR25–75% of those without previous injury. This may indicate that they are not fully recovered, despite participating fully in training and/or match play. This group is likely to benefit from a targeted intervention aiming to strengthen the adductors as recently described by Harøy et al.²⁷

Lower adduction strength has consistently been found to be a risk factor for groin injury.¹⁵ Whilst our findings were that adduction strength was more stable than abduction strength with a resultant drop in adduction/abduction ratio, we suggest performing eccentric adduction strength assessment as a monitoring tool throughout the season to detect early signs of groin injury. The stable strength outcomes found in this study throughout the season suggest that it is acceptable to assess strength at any given time, so if a player cannot attend testing (i.e. as a result of transfer), this can confidentially be performed at a later time. Current data serve as normal strength profiles for this specific population and can be used to guide decisions on additional training regimes to address strength imbalances²⁷ and future injury risk.^{14,15}

This prospective cohort study examined multiple follow-up time points within one season. It is the first study to report on repeated measurements of both strength and hip and groin functioning throughout a full season in adult professional male football players. This study included a high number of football players, with relatively low numbers of drop-outs during the season. All tests were performed by 6 experienced and well-trained physiotherapists who followed a standardised protocol.

Invitations for participation in this study were sent to 16 Dutch professional male football clubs, however 5 rejected this invitation. From participating clubs, 69% (217 of 313) of the players completed the baseline strength tests and at the end-of-the-season 168 football players (23% drop-out). An analysis was performed to investigate differences in baseline characteristics between participants and drop-outs, and demonstrated that drop-outs were a slightly higher age and therefore had greater years of football experience. No other differences were observed.

Whether our findings apply to professional female, youth or amateur football players, remains unknown and should be subject of future studies. In this study, previous groin injuries were self-reported for any time in the past. Due to this open timeline, there was a potential of recall bias. Furthermore, the previous (groin) injuries were self-reported, meaning that these injuries were not confirmed by medical staff and/or imaging. Previous self-reported injuries other than the groin were only recorded for the previous season (2014–2015) because of the high number of expected injuries, thereby limiting the risk of recall bias. Transfers before, during, and at end-of-season result in loss of personal medical data from players, therefore self-reporting of injuries was the preferred method chosen for this study.

5. Conclusion

Hip muscle strength and HAGOS normal values in professional male football players were obtained in a repeated fashion throughout one full season. Hip muscle strength remained stable during the season. A significant, though clinically irrelevant, increase in pain was observed during the season. Previous groin injury, injury other than the groin, and league level was not associated with hip muscle strength, while dominance had a small association with abduction strength. Previous groin injury and previous injury other than the groin were associated with worse HAGOS-scores.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:<https://doi.org/10.1016/j.jsams.2021.03.019>.

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