

Supplementary table 1. Eligibility criteria for hip and/or groin pain and control group

Table 1. Participant inclusion and exclusion criteria		
	Hip and/or groin pain group	Control group
Inclusion criteria	<ul style="list-style-type: none"> • Age: 18 to 50 years • Playing in a sub-elite football competition • Undertaking at least 2 sessions (games or training) of football (soccer/AF) per week • Self-reported hip (anterior/lateral/posterior) and/or groin pain which fulfilled criteria 1 to 3 <ol style="list-style-type: none"> 1. <i>Gradual onset</i> 2. <i>Greater than six months in duration</i> 3. <i>>3 and <8 on an 11-point NPRS* with football or football specific movements (squatting, kicking or cutting/change of direction)</i> + or - symptoms including clicking, giving way, locking or catching • Positive FADIR test in at least one hip 	<ul style="list-style-type: none"> • Age: 18 to 50 years • Playing in a sub-elite football competition • Undertaking at least 2 sessions (games or training) of football (soccer/AF) per week • Negative FADIR test in both hips
Exclusion criteria	<ul style="list-style-type: none"> • Self-reported history of significant hip or groin condition, specifically: <i>bursitis, congenital dislocation of the hip, fractures, osteochondritis dissecans, Legg-Calvé-Perthes disease, septic or rheumatoid arthritis, slipped capital femoral epiphysis or subluxations/dislocations</i> • Previous hip, groin or pelvic surgery • KL grade 2 or greater on AP pelvis radiograph • Any lumbar spine or lower limb injury/complaint in the previous 3 months (i.e. hamstring muscle injury or sprained ankle) that resulted in the inability to weight-bear fully or undertake testing procedures • Contra-indications to radiographs (i.e., pregnancy) or MRI (i.e., claustrophobia) • Received intra-articular hip injection (of any type) in the previous 3 months • Unable to understand spoken and written English 	<ul style="list-style-type: none"> • Self-reported history of hip and/or groin pain, or significant hip or groin condition (see symptomatic group exclusion criteria for details) • Past history of lower limb surgery (e.g., ACLR) • KL grade 2 or greater on AP pelvis radiograph • Any lumbar spine or lower limb injury/complaint in the previous 3 months (e.g. hamstring muscle injury or sprained ankle) that resulted in the inability to weight-bear fully or undertake testing procedures • Contra-indications to radiographs (i.e., pregnancy) or MRI (i.e., claustrophobia) • Unable to understand spoken and written English
ACLR, anterior cruciate ligament reconstruction; AF, Australian Football; AP, anteroposterior; FADIR, flexion adduction internal rotation; KL, Kellgren and Lawrence; MRI, magnetic resonance imaging; NPRS, numerical pain rating scale		

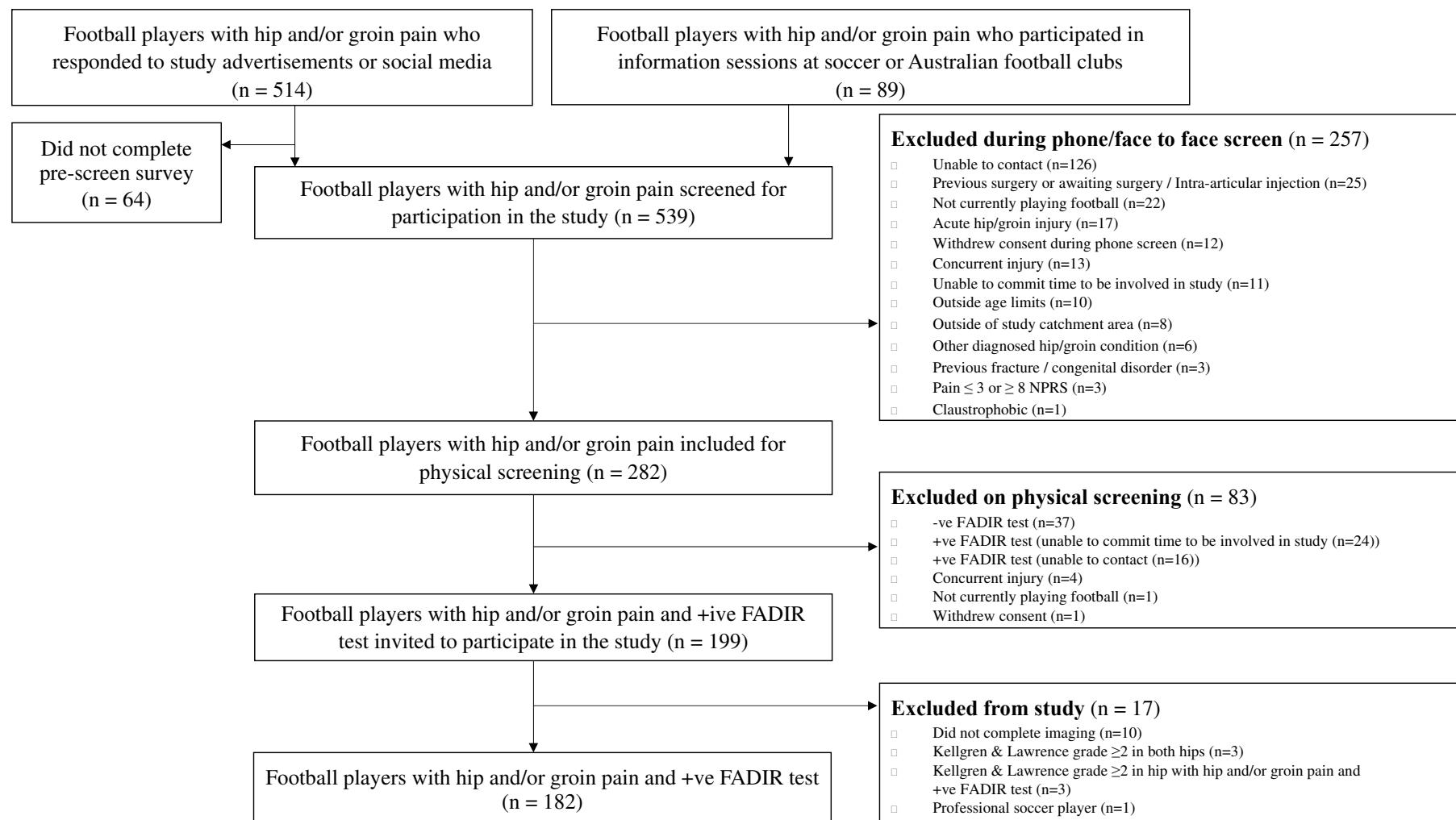
One investigator (RA) analysed hips for the presence of radiographic hip OA with the KL classification, with hip OA defined as a KL grade of ≥ 2 . [14] Substantial intra-rater agreement was found for KL grading ($\kappa = 0.87$) [7]
Use of the numerical pain rating scale in symptomatic football players is a deviation from the original study protocol [13]

Supplementary table 2. Magnetic resonance imaging protocol

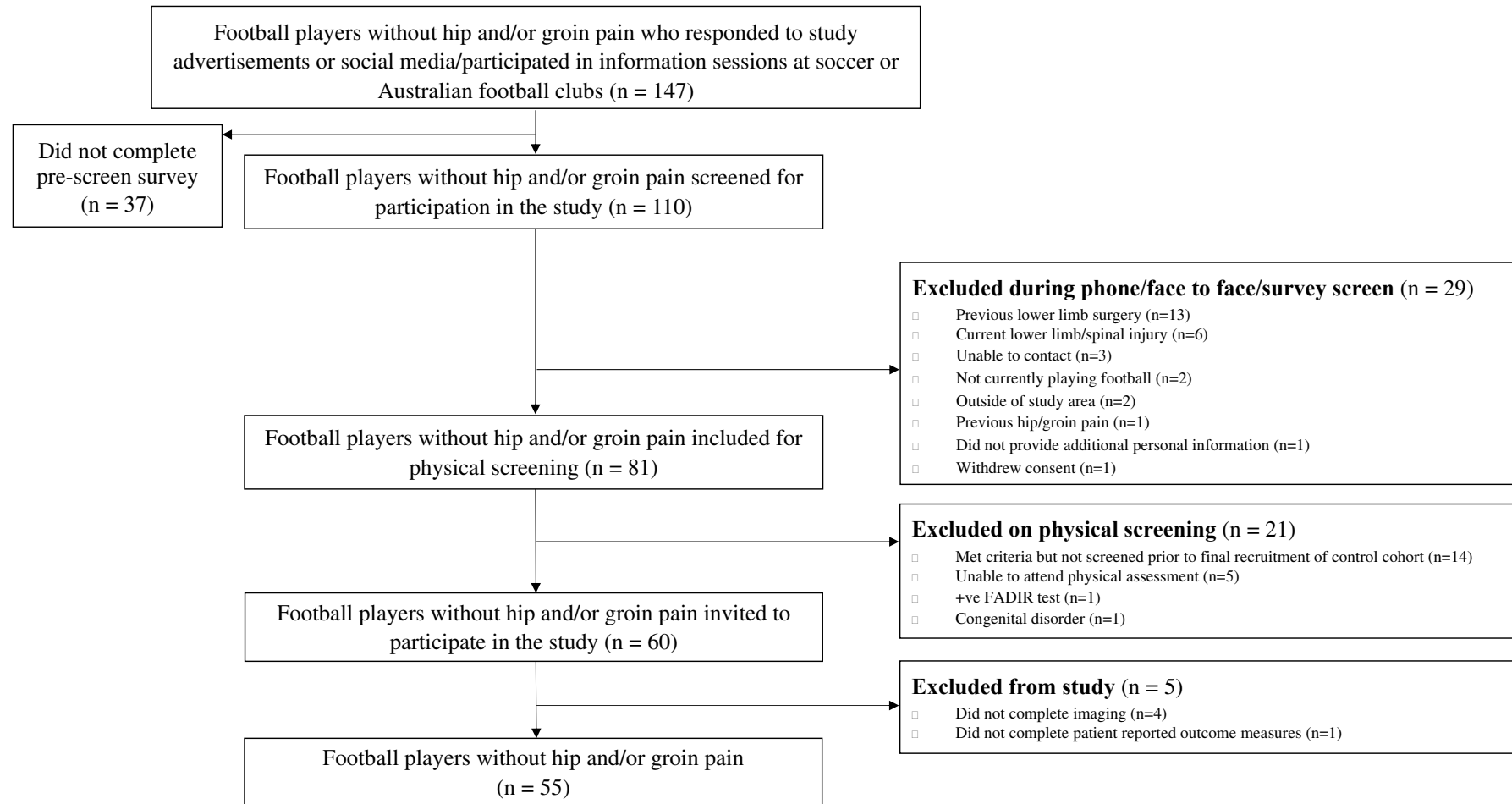
MRI Sequence	Coronal PD SPAIR	Sagittal PD SPAIR	Oblique axial PD SPAIR
Field of view (mm)	170 x 170	150 x 150	170 x 170
Slice thickness (mm)	2.5	2.5	2.5
Slice gap (mm)	1.5	1	1.5
Repetition time (ms)	2700	2675	3500
Echo time (ms)	25	25	25
Voxel size (mm)	0.70 x 0.70 x 2.5	0.7 x 0.75 x 2.5	0.75 x 0.75 x 2.5
Acquisition time (min:sec)	3:17	4:18	2:35

Abbreviations: PD; proton density; SPAIR, spectral attenuated inversion recovery

Supplementary figure 1. Participant flow chart hip and/or groin pain group



Supplementary figure 2. Participant flow chart control group



Supplementary table 3. Predicted probability from 0 (0%) to 1 (100%) of cartilage defects and labral tears (presence) for values of alpha angle in 5° increments for all hips (hip and/or groin pain and control)

Alpha angle	Probability of cartilage defect % (95%CI)		Probability of labral tear % (95%CI)	
	AP	Dunn 45°	AP	Dunn 45°
40°	38 (29, 46)	37 (25, 49)	62 (54, 71)	57 (44, 71)
45°	41 (33, 48)	39 (29, 50)	65 (58, 72)	60 (49, 71)
50°	44 (37, 51)	42 (32, 51)	67 (61, 73)	63 (54, 72)
55°	47 (41, 53)	44 (36, 52)	70 (64, 75)	65 (58, 73)
60°	50 (44, 56)	46 (39, 53)	72 (66, 77)	68 (62, 74)
65°	53 (47, 60)	49 (42, 55)	74 (68, 79)	70 (65, 76)
70°	57 (50, 64)	51 (45, 57)	76 (70, 82)	73 (67, 78)
75°	60 (52, 68)	53 (46, 60)	78 (71, 84)	75 (69, 81)
80°	63 (54, 71)	56 (48, 64)	79 (72, 86)	77 (70, 83)
85°	66 (56, 75)	58 (49, 67)	81 (74, 89)	79 (72, 86)
90°	69 (58, 79)	60 (50, 71)	83 (75, 91)	81 (73, 89)
95°	71 (60, 82)	62 (51, 74)	84 (76, 92)	82 (74, 91)
100°	74 (63, 85)	65 (51, 78)	85 (77, 94)	84 (75, 93)
105°	76 (65, 88)	67 (52, 81)	87 (78, 95)	85 (76, 95)
110°	79 (67, 91)	69 (53, 85)	88 (79, 97)	87 (77, 97)

Adjusted for age, sex, body mass index, KL grade and symptoms
AP, anteroposterior

Supplementary table 4. Association between alpha angle and cartilage defects (location) for all hips (hip and/or groin pain and control)

Radiographic variable	Cartilage defect	
	Unadjusted OR (95%CI) <i>P</i> -value	Adjusted OR (95%CI)* <i>P</i> -value
	Superolateral subregion	
Alpha angle (AP view)	1.04 (1.02, 1.05) <0.001	1.03 (1.02, 1.05) <0.001
Alpha angle (Dunn 45° view)	1.04 (1.03, 1.06) <0.001	1.04 (1.02, 1.05) <0.001
	Superomedial subregion	
Alpha angle (AP view)	1.00 (0.98, 1.02) 0.936	1.00 (0.98, 1.02) 0.975
Alpha angle (Dunn 45° view)	0.99 (0.96, 1.01) 0.381	0.99 (0.96, 1.01) 0.302
	Lateral subregion	
Alpha angle (AP view)	1.01 (0.99, 1.02) 0.299	1.01 (0.99, 1.02) 0.303
Alpha angle (Dunn 45° view)	1.00 (0.98, 1.01) 0.767	1.00 (0.98, 1.01) 0.700

*Adjusted for age, sex, body mass index, KL grade and symptoms
AP, anteroposterior; OR, odds ratio

Supplementary table 5. Association between alpha angle and labral tears (location) for all hips (hip and/or groin pain and control)

Radiographic variable	Labral tear	
	Unadjusted OR (95%CI) <i>P</i> -value	Adjusted OR (95%CI)* <i>P</i> -value
	Superior subregion	
Alpha angle (AP view)	1.03 (1.02, 1.05) <0.001	1.03 (1.02, 1.05) <0.001
Alpha angle (Dunn 45° view)	1.03 (1.02, 1.05) <0.001	1.03 (1.01, 1.04) 0.003
	Anterosuperior subregion	
Alpha angle (AP view)	1.00 (0.99, 1.02) 0.499	1.01 (0.99, 1.02) 0.342
Alpha angle (Dunn 45° view)	1.01 (0.99, 1.02) 0.280	1.01 (1.00, 1.03) 0.128

*Adjusted for age, sex, body mass index, KL grade and symptoms
AP, anteroposterior; OR, odds ratio

Supplementary table 6. Predicted probability from 0 (0%) to 1 (100%) of cartilage defects and labral tears (location) for values of alpha angle in 5° increments for all hips (hip and/or groin pain and control)

Alpha angle	Probability of superolateral cartilage defect % (95%CI)		Probability of superior labral tear % (95%CI)	
	AP	Dunn 45°	AP	Dunn 45°
40°	25 (18, 32)	19 (10, 27)	24 (17, 31)	23 (13, 32)
45°	28 (21, 35)	22 (13, 30)	27 (21, 33)	25 (16, 34)
50°	31 (25, 38)	25 (17, 33)	30 (24, 36)	28 (20, 35)
55°	35 (29, 41)	28 (21, 35)	34 (28, 39)	30 (23, 37)
60°	39 (33, 45)	32 (26, 38)	37 (32, 43)	33 (27, 39)
65°	43 (37, 49)	36 (30, 42)	41 (35, 47)	36 (30, 42)
70°	47 (40, 54)	40 (34, 46)	45 (38, 51)	39 (33, 45)
75°	51 (43, 59)	44 (38, 51)	49 (41, 56)	42 (36, 49)
80°	55 (46, 64)	49 (41, 57)	52 (44, 61)	45 (38, 53)
85°	59 (49, 69)	53 (44, 63)	56 (47, 66)	49 (39, 58)
90°	63 (52, 74)	58 (47, 68)	60 (49, 71)	52 (41, 63)
95°	67 (55, 78)	62 (50, 74)	64 (52, 76)	55 (43, 67)
100°	70 (58, 82)	66 (53, 79)	67 (55, 80)	58 (44, 72)
105°	74 (61, 86)	70 (56, 84)	71 (58, 84)	61 (46, 77)
110°	77 (64, 89)	73 (59, 88)	74 (60, 87)	64 (48, 81)

Adjusted for age, sex, body mass index, KL grade and symptoms
AP, anteroposterior

Supplementary table 7. Association between alpha angle and cartilage defects (severity) for all hips (hip and/or groin pain and control)

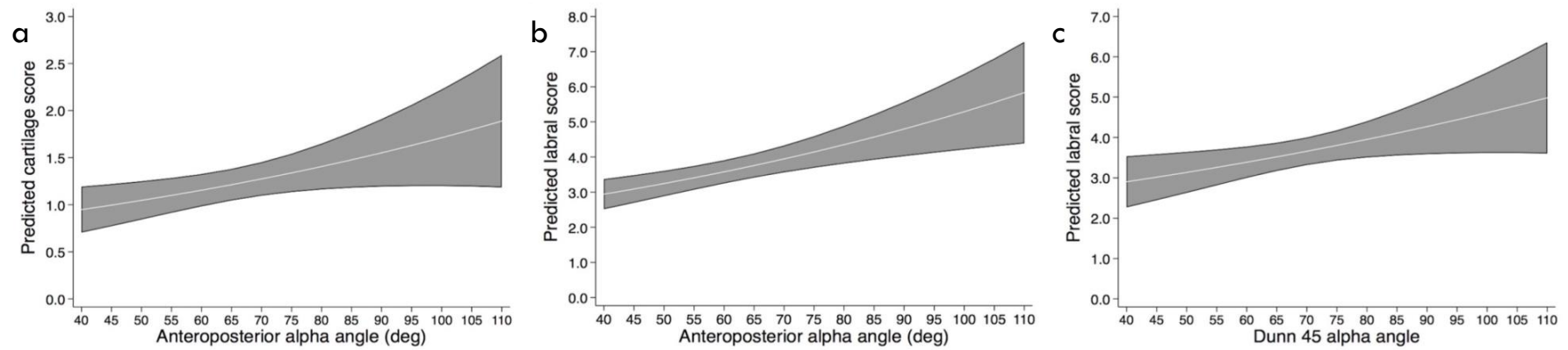
Radiographic variable	No. of hips	Cartilage score	
		Unadjusted IRR (95%CI) <i>P</i> -value	Adjusted IRR (95%CI)* <i>P</i> -value
Alpha angle (AP view)	398	1.01 (1.01, 1.02) 0.001	1.01 (1.00, 1.02) 0.017
Alpha angle (Dunn 45° view)	382	1.01 (1.00, 1.02) 0.074	1.00 (0.99, 1.01) 0.476

*Adjusted for age, sex, body mass index, KL grade and symptoms
AP, anteroposterior; IRR, incidence-rate ratio

Supplementary table 8. Association between alpha angle and labral tears (severity) for all hips (hip and/or groin pain and control)

Radiographic variable	No. of hips	Labral score	
		Unadjusted IRR (95%CI) <i>P</i> -value	Adjusted IRR (95%CI)* <i>P</i> -value
Alpha angle (AP view)	398	1.01 (1.01, 1.02) <0.001	1.01 (1.00, 1.01) <0.001
Alpha angle (Dunn 45° view)	382	1.01 (1.00, 1.01) 0.013	1.01 (1.00, 1.01) 0.021

*Adjusted for age, sex, body mass index, KL grade and symptoms
AP, anteroposterior; IRR, incidence-rate ratio

Supplementary figure 3. Predicted cartilage defect and labral tear (severity) for 5° increase in alpha angle for all hips (hip and/or groin pain and control)

a) cartilage score (anteroposterior alpha angle); b) labral score (anteroposterior alpha angle); c) labral score (Dunn 45° alpha angle)

Supplementary table 9. Predicted cartilage defect and labral tear (severity) for values of alpha angle in 5° increments for all hips (hip and/or groin pain and control)

Alpha angle (AP)	Predicted cartilage score (95%CI)		Predicted labral score (95%CI)	
	AP		AP	Dunn 45°
40°	0.95 (0.70, 1.19)		2.94 (2.52, 3.37)	2.90 (2.27, 3.53)
45°	1.00 (0.77, 1.22)		3.09 (2.70, 3.48)	3.02 (2.45, 3.58)
50°	1.05 (0.84, 1.25)		3.24 (2.89, 3.60)	3.13 (2.63, 3.64)
55°	1.10 (0.92, 1.28)		3.41 (3.07, 3.74)	3.26 (2.82, 3.70)
60°	1.15 (0.98, 1.33)		3.58 (3.25, 3.90)	3.39 (3.00, 3.77)
65°	1.21 (1.05, 1.38)		3.76 (3.42, 4.10)	3.52 (3.17, 3.87)
70°	1.27 (1.10, 1.45)		3.94 (3.57, 4.32)	3.66 (3.32, 4.00)
75°	1.34 (1.14, 1.54)		4.14 (3.70, 4.59)	3.80 (3.43, 4.17)
80°	1.41 (1.16, 1.65)		4.35 (3.82, 4.88)	3.95 (3.51, 4.40)
85°	1.48 (1.18, 1.77)		4.57 (3.93, 5.21)	4.11 (3.56, 4.66)
90°	1.55 (1.19, 1.91)		4.80 (4.03, 5.56)	4.27 (3.59, 4.95)
95°	1.63 (1.20, 2.06)		5.04 (4.12, 5.95)	4.44 (3.61, 5.27)
100°	1.71 (1.20, 2.22)		5.29 (4.22, 6.36)	4.61 (3.62, 5.61)
105°	1.80 (1.19, 2.40)		5.55 (4.30, 6.80)	4.79 (3.61, 5.97)
110°	1.89 (1.18, 2.59)		5.83 (4.39, 7.28)	4.98 (3.60, 6.36)

Adjusted for age, sex, body mass index, KL grade and symptoms
AP, anteroposterior

Supplementary table 10. Interaction between alpha angle and symptoms for cartilage defects (presence)

Radiographic variable	No. of hips	Cartilage defect	Interaction term§
		Adjusted OR (95%CI)*	P-value
Alpha angle (AP view)			
Control	110	1.02 (1.00, 1.05)	0.756
Hip and/or groin pain	288	1.03 (1.01, 1.04)	
Alpha angle (Dunn 45° view)			
Control	108	1.03 (0.99, 1.06)	0.659
Hip and/or groin pain	274	1.02 (1.00, 1.04)	

* Adjusted for age, sex, body mass index and KL grade
§ Alpha angle by presence of symptoms (hip and/or groin pain and positive FADIR test)
AP, anteroposterior; OR, odds ratio

Supplementary table 11. Interaction between alpha angle and symptoms for labral tears (presence)

Radiographic variable	No. of hips	Labral tear	Interaction term§
		Adjusted OR (95%CI)*	P-value
Alpha angle (AP view)			
Control	110	1.03 (1.00, 1.05)	0.662
Hip and/or groin pain	288	1.02 (1.00, 1.04)	
Alpha angle (Dunn 45° view)			
Control	108	1.01 (0.98, 1.05)	0.477
Hip and/or groin pain	274	1.03 (1.00, 1.05)	

* Adjusted for age, sex, body mass index and KL grade
§ Alpha angle by presence of symptoms (hip and/or groin pain and positive FADIR test)
AP, anteroposterior; OR, odds ratio

Supplementary table 12. Interaction between alpha angle and symptoms for cartilage defects (location)

Radiographic variable	No. of hips	Cartilage defect	Interaction term§
		Adjusted OR (95%CI)*	P-value
Superolateral subregion			
Alpha angle (AP view)			
Control	110	1.03 (1.01, 1.06)	0.749
Hip and/or groin pain	288	1.03 (1.02, 1.05)	
Alpha angle (Dunn 45° view)			
Control	108	1.04 (1.00, 1.08)	0.822
Hip and/or groin pain	274	1.03 (1.01, 1.06)	
Superomedial subregion			
Alpha angle (AP view)			
Control	110	0.96 (0.89, 1.03)	0.213
Hip and/or groin pain	288	1.01 (0.98, 1.03)	
Alpha angle (Dunn 45° view)			
Control	108	0.99 (0.92, 1.07)	0.833
Hip and/or groin pain	274	0.98 (0.96, 1.01)	
Lateral subregion			
Alpha angle (AP view)			
Control	110	1.00 (0.97, 1.02)	0.451
Hip and/or groin pain	288	1.01 (0.99, 1.03)	
Alpha angle (Dunn 45° view)			
Control	108	1.00 (0.97, 1.04)	0.642
Hip and/or groin pain	274	0.99 (0.98, 1.01)	

* Adjusted for age, sex, body mass index and KL grade
§ Alpha angle by presence of symptoms (hip and/or groin pain and positive FADIR test)
AP, anteroposterior; OR, odds ratio

Supplementary table 13. Interaction between alpha angle and symptoms for labral tears (location)

Radiographic variable	No. of hips	Labral tear	Interaction term§
		Adjusted OR (95%CI)*	P-value
Superior subregion			
Alpha angle (AP view)			
Control	110	1.04 (1.01, 1.07)	0.484
Hip and/or groin pain	288	1.03 (1.01, 1.04)	
Alpha angle (Dunn 45° view)			
Control	108	1.03 (0.99, 1.06)	0.937
Hip and/or groin pain	274	1.03 (1.01, 1.05)	
Anterosuperior subregion			
Alpha angle (AP view)			
Control	110	1.02 (1.00, 1.04)	0.189
Hip and/or groin pain	288	1.00 (0.99, 1.02)	
Alpha angle (Dunn 45° view)			
Control	108	1.02 (0.99, 1.05)	0.616
Hip and/or groin pain	274	1.01 (0.99, 1.03)	

* Adjusted for age, sex, body mass index and KL grade
§ Alpha angle by presence of symptoms (hip and/or groin pain and positive FADIR test)
AP, anteroposterior; OR, odds ratio

Supplementary table 14. Interaction between alpha angle and symptoms for cartilage defects (score)

Radiographic variable	No. of hips	Cartilage score	Interaction term§
		Adjusted IRR (95%CI)*	P-value
Alpha angle (AP view)			
Control	110	1.00 (0.99, 1.02)	0.393
Hip and/or groin pain	288	1.01 (1.00, 1.02)	
Alpha angle (Dunn 45° view)			
Control	108	1.01 (0.99, 1.03)	0.859
Hip and/or groin pain	274	1.00 (0.99, 1.01)	

* Adjusted for age, sex, body mass index and KL grade
§ Alpha angle by presence of symptoms (hip and/or groin pain and positive FADIR test)
AP, anteroposterior; IRR, incidence-rate ratio

Supplementary table 15. Interaction between alpha angle and symptoms for labral tears (score)

Interaction between alpha angle and symptoms for labral tears (score)			
Radiographic variable	No. of hips	Labral score	Interaction term§
		Adjusted IRR (95%CI)*	P-value
Alpha angle (AP view)			
Control	110	1.01 (1.00, 1.02)	0.590
Hip and/or groin pain	288	1.01 (1.00, 1.01)	
Alpha angle (Dunn 45° view)			
Control	108	1.01 (0.99, 1.02)	0.889
Hip and/or groin pain	274	1.01 (1.00, 1.01)	

* Adjusted for age, sex, body mass index and KL grade
§ Alpha angle by presence of symptoms (hip and/or groin pain and positive FADIR test)
AP, anteroposterior; IRR, incidence-rate ratio