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Normal hip strength and range of motion values in youth and adult female national football teams: Data from 504 assessments

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ABSTRACT

Objectives: To determine normal hip adduction- and abduction strength and range of motion (ROM) values for youth and adult female national team football players, and evaluate if increasing age, playing position and leg dominance were associated with these strength and ROM values.
Design: Cohort study.
Setting: National football center.
Participants: 344 unique asymptomatic female football players.
Main outcome measures: Hip internal/external rotation (°), Bent Knee Fall Out test (cm), hip adduction/abduction strength(N) and ratio, and normalised hip adduction/abduction torque (Nm/kg).
Results: A total of 504 assessments were performed. A total of 107 players underwent two (n = 67), three (n = 27) or four (n = 13) assessments. Mean peak hip adduction strength was 39% greater in 20 + Y old players 170 (±53 N) than in 13Y old players 122 (±28 N). Normalised hip adduction torque was 9% greater: 2.5 (±0.8Nm/kg) versus 2.3 (±0.5Nm/kg). A positive association between age and all strength measurements was found, while a negative association between age and hip external rotation and total hip rotation was found. No clinically relevant differences were found for the associations between playing position, leg dominance and hip strength- and ROM values.
Conclusion: Normal values for hip strength and range of motion in youth and adult female national football players are presented that can be used as clinical reference values.

1. Introduction

A hip and/or groin injury is the most prevalent non time-loss injury in female football (17%) (Langhout et al., 2018). Several risk factors for hip and groin injuries have been identified, mainly based on research in male athletes (Mosler et al., 2018; Ryan et al., 2014; Whittaker et al., 2015). The main risk factors for hip- and groin injuries are a previous hip- or groin injury (non-modifiable) and a reduced hip adduction strength (modifiable) (Ryan et al., 2014; Whittaker et al., 2015). Evidence on hip range of motion (ROM) as a risk factor for hip- and groin injuries is conflicting (Ryan et al., 2014; Tak et al., 2017). A systematic review found that a reduced total rotational (internal + external rotation) ROM of both hips may be a risk factor for hip- and groin pain, while internal and external rotation in isolation were not (Tak et al., 2017). A reduced hip ROM is also more common in athletes presenting with hip- and groin pain (Mosler et al., 2015).

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Measuring modifiable risk factors (hip strength and rotational ROM values) may be relevant for (1) identifying athletes potentially at risk for hip and groin injuries (Tyler et al., 2001), (2) developing prevention programmes (Finch, 2006; Whittaker et al., 2015), (3) monitoring athletes' rehabilitation progress (Serner et al., 2020), and (4) return to play decision making (Nicholas & Tyler, 2002). For treatment monitoring and return to play decision making, strength deficits between the injured and uninjured leg are often considered an important clinical milestone for various lower extremity injuries (Abrams et al., 2014). However, athletes with hip- and groin pain often have bilateral symptoms (Heijboer et al., 2022). Normal values from non-injured athletes may provide a better comparison in such instances (Mosler et al., 2017). Normal values for hip strength and ROM have been established in several men's football and hockey codes, (Beddows et al., 2020; Mosler et al., 2017) but this research is limited in female football.

Only three studies evaluated hip adduction- and abduction strength profiles in female football codes: one in Australian football players (n = 85) (Mentiplay et al., 2019), one in mainly senior female football players (n = 82) (Jaenada-Carrilero, 2024) and one in adolescent female football players (n = 418) (Fältström et al., 2022). Fältström et al. (Fältström et al., 2022) performed a 1-year follow-up in a sub-cohort of 12–17 year old players and found an increase in absolute hip strength in female adolescent football players as players age, but not when adjusted for leg length and body mass. Interestingly, an increase in hip external and internal rotation was found in this study, however, differences were small and potentially not clinically relevant. These age specific differences imply that strength and range of motion values differ between age groups. A larger range of age groups and longer follow-up in a homogenous cohort may provide improved estimation of age specific differences between hip strength- and ROM.

Conflicting evidence exists on the association between limb dominance and hip strength. A study in male senior football players found an increased hip adduction strength in the dominant leg in elite football players (Thorborg et al., 2009), while other studies did not find this association (Fältström et al., 2022; Mentiplay et al., 2019; Mosler et al., 2017). The role of playing position has not been investigated yet in female football. We postulated that strength and ROM profiles may differ between goal keepers and field players, due to differing physical position-specific demands (White et al., 2018).

Our primary aim was to determine the normal hip adduction- and abduction strength and range of motion values for national team female youth and senior football players, stratified per age group. The secondary aim was to evaluate if increasing age, playing position (goal keeper vs field player) and leg dominance are associated with strength and range of motion values.

2. Methods

2.1. Design

2.1.1. Cohort study

2.1.1.1. Study participants. Study participants were female football players selected for the national football teams from the Netherlands (Under (U)14, U15, U16, U17, U19, U20, U23, senior national team). Players with a current episode of hip- and/or groin pain were not tested, and therefore not included in the present study. Data was collected as part of their standardized pre-participation clinical assessment between February 2015 and March 2020. An ethics exemption was obtained from the Medical Ethics Review Committee of the Academic Medical Center, Amsterdam, The Netherlands (reference number W21_040 # 21.045).

2.1.1.2. Study procedures. Clinical assessments were performed once every 1.5–2 years, meaning some players underwent two, three or four assessments between 2015 and 2020 depending on their age and if they remained selected for the national squad. Assessments were performed by 8 sports medicine physicians from the Royal Netherlands Football Association. A training session for all sports medicine physicians was held prior to data collection to align data collection procedures. The hip ROM and strength-tests that were performed as part of this standardized screening, are described in detail below.

The assessment started with a standardised health and injury questionnaire filled in by the player. Hip ROM and strength testing was performed without a warm-up.

3. Range of motion

3.1. Hip internal and external rotation

Maximal hip internal and external rotation (°) were measured with the player in supine position (Fig. 1a and b). The hip and knee of the tested leg were both flexed in 90°. Maximal passive internal and external rotation (with neutral pelvis position) were measured with a goniometer (Lafayette Gollehon Extendable Goniometer) (Mosler et al., 2017). The moving arm was aligned to the upper leg, while the stationary arm was aligned parallel to the contralateral leg (vertical line). Range of motion was rounded off by the clinician to the closest 5° during the screening procedure and recorded. Subsequently, maximal total rotational ROM of was calculated by adding up the degrees of external and internal rotation for each hip. Reliability values were not measured in the present study. A similar measurement approach found acceptable inter-rater intra-class correlation coefficients (ICC) of 0.76, 95%CI 0.58–0.86 and 0.89, 95%CI 0.80–0.94 for hip internal and external rotation, respectively (Mosler et al., 2017). Standard error of measurement (SEM) was found to be ~2–4° (up to ~14%) for maximal hip internal rotation, and ~3–4° (up to ~11%) for maximal hip external rotation in previous studies (Mosler et al., 2017; Nussbaumer et al., 2010).

3.2. Bent Knee Fall Out (BKFO)

The BKFO test was performed with the player in supine position (Fig. 1c). (Malliaras et al., 2009) Both hips were positioned in 45°, the knees in 90° and the feet together. Players were instructed to let their knees fall outwards while keeping their feet together. The examiner applied gentle overpressure to ensure the player had relaxed at the end of the range of movement. The distance between the most distal point on the head of the fibula and the surface of the examination bed was measured using an inflexible tape measure (to the nearest 0.5 cm). This test was conducted once (Mosler et al., 2017). An inter-rater intra-class correlation coefficients (ICC) of 0.93, 95%CI 0.90–0.96 (SEM = 1 cm (9%)) was previously found for this approach (Mosler et al., 2017).

4. Hip strength

4.1. Hip adduction and abduction strength

Peak eccentric hip adduction and hip abduction strength (Fig. 1d and e) were assessed with a Hand Held Dynamometer (HHD, type MicroFET). Reduced peak eccentric hip adduction strength ("break" test measured from side lying position) is a known risk factor for adductor muscle strains (Tyler et al., 2001), and eccentric hip adduction strength deficits are often present in athletes presenting with adductor-related groin pain (Thorborg et al., 2014). Detailed descriptions of the test procedures were described by Thorborg et al. (Thorborg et al., 2009) In brief, the tested player was positioned in side-lying position with the tested leg straight and the non-tested leg in 90° hip and 90° knee flexion. The examiner placed the HHD 8 cm proximal to the most prominent point of the lateral malleolus for hip abduction and at the same level medially for hip adduction. The player performed a maximum voluntary isometric contraction against the HHD for 3 s, followed by 2 s "break" where the examiner slowly pushed the leg towards the examination

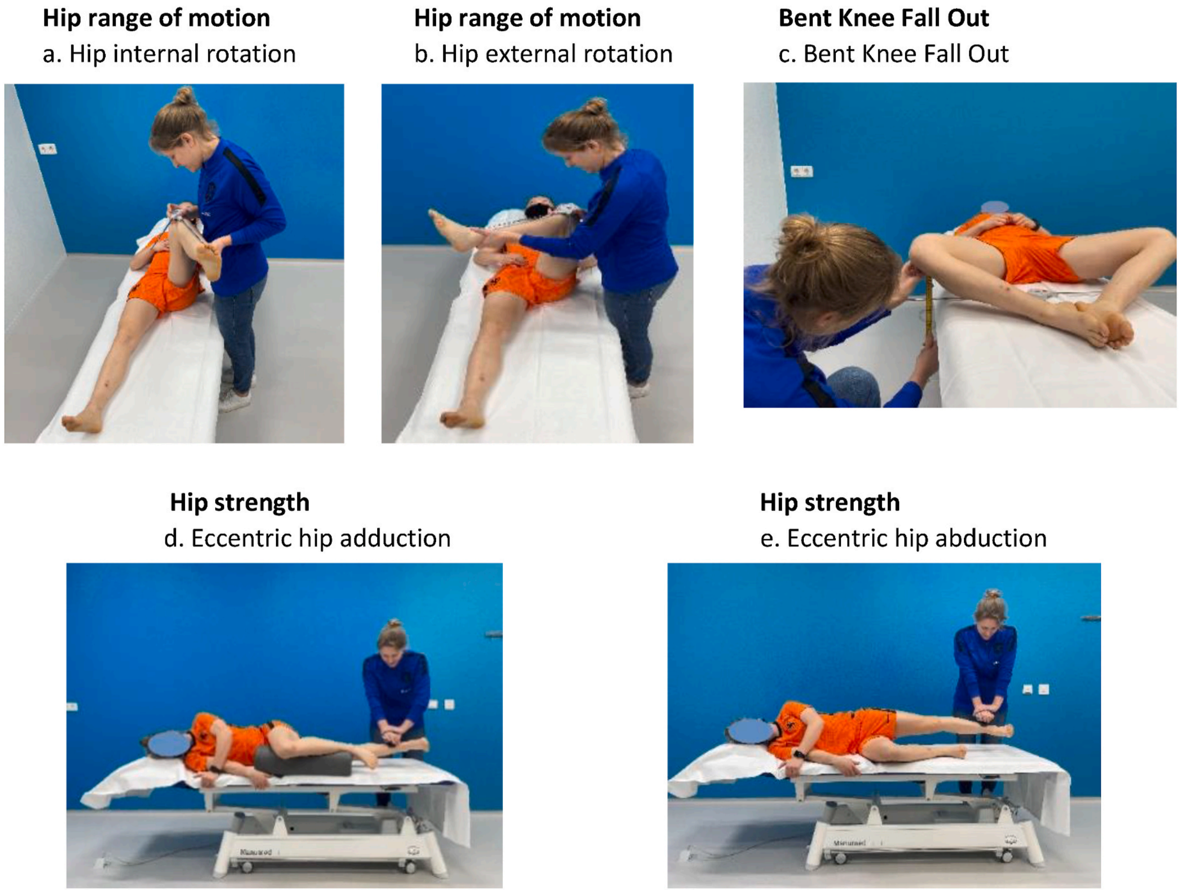

Fig. 1. Testing positions of hip range of motion (a–c) and strength (d, e) measurements.

table. Players performed one practice trial. The test was repeated until a force plateau (Newton, N) of <5% between 2 consecutive sessions was reached and the mean of these values was calculated. The rest period between each trial was 60 s. These strength tests have shown good to excellent reliability in previous research. For eccentric hip adduction strength testing, an intra-rater ICC = 0.89 was reported (Krause et al., 2007), and an inter-rater ICC = 0.91 with a Standard Error of Measurement of 6.3% (Thorborg et al., 2009). For eccentric hip abduction strength testing, an intra-rater ICC = 0.91 was reported (Krause et al., 2007), and an inter-rater ICC = 0.86 with a Standard Error of Measurement of 5.1% (Thorborg et al., 2009). Normalised torque was calculated by adjusting for leg length and body mass (Nm/kg). Leg length was measured from the anterior superior iliac spine to 8 cm proximal to the proximal edge of the lateral malleolus. The hip adduction:abduction strength ratio was calculated by dividing the absolute hip adduction strength (N) by the hip abduction strength (N).

5. Statistical analysis

Hip strength (N), normalised torque (Nm/kg), ROM (°) and BKFO

Table 1
Participants characteristics and average test scores for all screenings based on cross-sectional analysis, stratified by age group.

	13Y (n = 99)[a]	14Y (n = 59)	15Y (n = 79)	16Y (n = 66)	17Y (n = 49)	18Y (n = 59)	19Y (n = 32)	20 + Y (n = 61)[b]
Height (cm)	162 ± 6	165 ± 6	167 ± 5	169 ± 6	169 ± 6	168 ± 6	170 ± 7	170 ± 6
Body mass (kg)	50 ± 6	56 ± 7	58 ± 7	62 ± 7	63 ± 6	63 ± 7	64 ± 7	64 ± 6
Body Mass Index (BMI)	19 ± 2	20 ± 2	21 ± 2	22 ± 2	22 ± 2	22 ± 2	22 ± 2	22 ± 2
Hip internal rotation (∘)	39 ± 9	37 ± 7	36 ± 9	33 ± 7	35 ± 9	36 ± 9	34 ± 8	36 ± 8
Hip external rotation (∘)	51 ± 6	48 ± 6	50 ± 7	47 ± 6	48 ± 7	44 ± 7	46 ± 7	45 ± 5
Total hip rotation (∘)	89 ± 11	86 ± 11	86 ± 11	80 ± 10	83 ± 11	81 ± 12	80 ± 12	81 ± 10
Bent Knee Fall Out (cm)	15 ± 3	16 ± 4	15 ± 4	15 ± 4	16 ± 4	14 ± 4	14 ± 4	15 ± 4
Hip adduction strength (N)	122 ± 28	128 ± 34	129 ± 31	136 ± 36	147 ± 43	170 ± 41	166 ± 44	170 ± 53
Hip abduction strength (N)	118 ± 26	127 ± 25	138 ± 29	144 ± 28	157 ± 28	158 ± 32	173 ± 26	167 ± 31
Normalised hip adduction torque (Nm/kg)	2.3 ± 0.5	2.2 ± 0.5	2.1 ± 0.5	2.1 ± 0.6	2.2 ± 0.6	2.5 ± 0.6	2.5 ± 0.7	2.5 ± 0.8
Normalised hip abduction torque (Nm/kg)	2.2 ± 0.5	2.1 ± 0.4	2.3 ± 0.4	2.2 ± 0.4	2.4 ± 0.4	2.4 ± 0.5	2.6 ± 0.4	2.5 ± 0.4
Hip adduction:abduction strength ratio	1.0 ± 0.2	1.0 ± 0.2	1.0 ± 0.2	1.0 ± 0.2	0.9 ± 0.2	1.1 ± 0.2	1.0 ± 0.2	1.0 ± 0.2

Y = Years, cm = centimetres, kg = kilograms, N = Newton, m = meter.
Data are presented as mean ± SD. Values for strength and range of motion are peak/maximal values. Forty-one players (12%) were goal keepers.
[a] Eight players in this group were 12 years old (median 12 years and 9 months).
[b] Median age 22.7Y, interquartile range 21,1Y – 24,4Y.

(cm) values were stratified by age (13Y, 14Y, 15Y, 16Y, 17Y, 18Y, 19Y, 20 + Y). Descriptive data were analysed and presented as cross-sectional data (Table 1; Figs. 2 and 3). Mean ± standard deviation (SD) was reported for normally distributed data, median and interquartile range (IQR) for non-normally distributed data. Subsequent grouping of normal values was performed as presented in previous research based on mean and SD values (Beddows et al., 2020; Mosler et al., 2017).

Linear mixed model analysis was performed to evaluate if increasing age (as continuous variable) and playing position (goal keeper vs field player) were associated with hip adduction- and abduction strength, torque, and hip ROM values. Age and playing position (goalkeeper vs field player) were entered as fixed effect. Hip strength (N), normalised hip torque (Nm/kg) and ROM (°) values were entered as dependent variables. Covariates included body mass index (BMI), the right/left leg within the same participant and time (for multiple measurements). BMI was excluded as a covariate for the specific analysis with normalised hip torque as the dependent variable, since normalised hip torque already adjusts for leg length and weight. A random intercept was used, since players were tested at different ages. Time was used as a random effect in the final model based on the smallest Akaike Information Criterion. Any potential differences between the dominant and non-dominant leg were analysed using a paired T-test (two-sided). Players without a self-reported dominant leg (i.e. reporting both legs are dominant) were excluded for this specific analysis. Asymmetry values (%) between both limbs were calculated by: (strong – weaker)/stronger x 100 as recommended by previous research (Bishop et al., 2018; Impellizzeri et al., 2007). A p-value <0.05 was considered statistically significant. Analysis was performed in Rstudio (RStudio Team (2020). RStudio: Integrated Development for R. RStudio, PBC, Boston, MA URL http://www.rstudio.com/). The "nlme" package was used for linear mixed model analysis.

6. Results

A total of 504 clinical assessments were performed among 344 unique female players with no current hip- or groin pain. A total of 107 players underwent two (n = 67, 63%), three (n = 27, 25%) or four (n = 13, 12%) assessments. Forty-one players (12%) were goal keepers. Both sides were tested, thus in total, data from 1008 hip strength and range of motion tests were analysed. Table 1 presents the participants characteristics and average test scores, stratified by age group. Eight players were selected for the U14 group, but were not 13 years old yet (median 12 years and 9 months). These players were stratified in the "13Y" group. A full overview of all mean (±SD) hip ROM and strength values is presented in Appendix A. Appendix B presents scatterplots of the relationship between age and all hip ROM and strength values. Appendix C presents differences between the dominant and non-dominant leg (n = 59 players without a self-reported dominant leg were excluded from this specific analysis), and the median asymmetry (%) between both hips for all ROM and strength tests.

7. Range of motion

The mean peak hip internal rotation was 39° in 13Y old players compared to 36° in 20 + Y old players (−8%), while the mean peak hip external rotation was 51° in 13Y old players compared to 45° in 20 + Y old players (−12%) (Fig. 2).

7.1. Linear mixed model analysis

Linear mixed model analysis revealed no association between age (p = 0.38), BMI (p = 0.37) and maximal hip internal rotation, although age (β = -0.35, 95% CI: -0.55 to -0.15, p < 0.01), and BMI (β = -0.84, 95% CI: -1.14 to -0.53, p < 0.001) were negatively associated with maximal hip

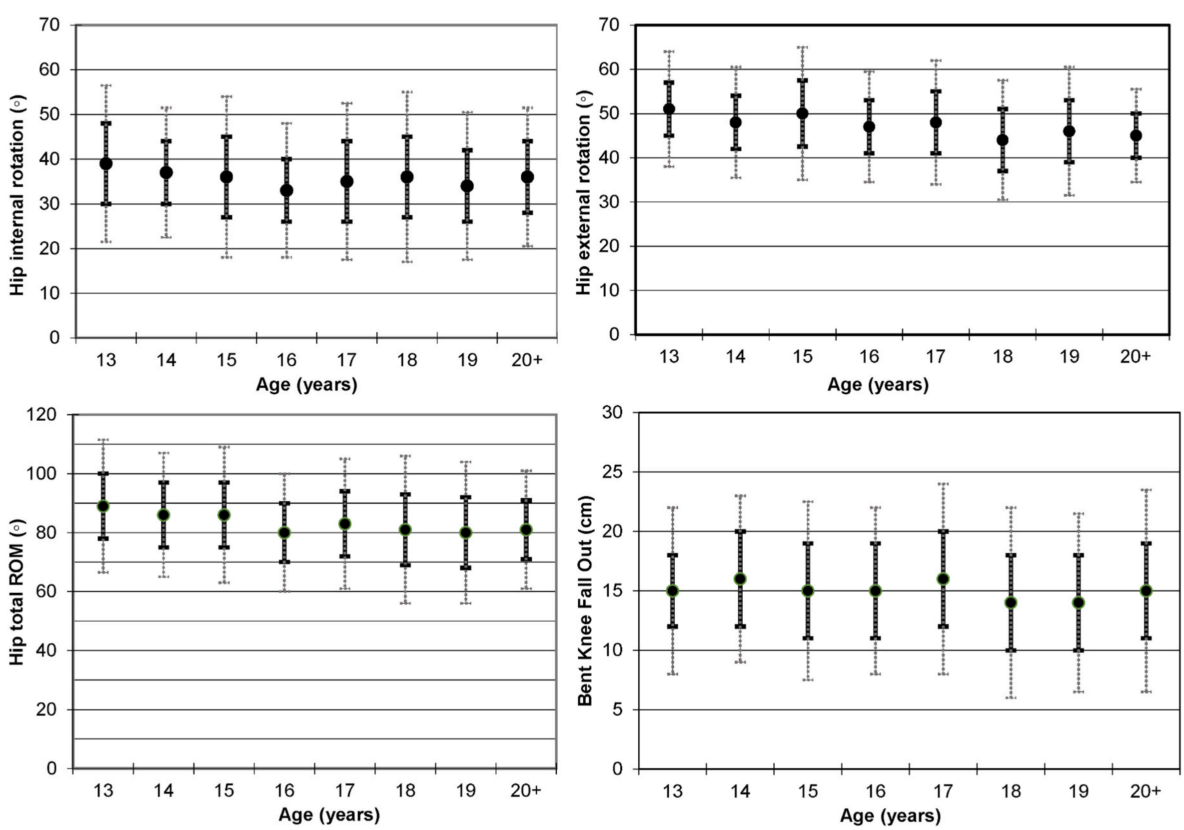

Fig. 2. Mean (●), 1 standard deviation (line) and 2 standard deviation (dotted line) values for maximal hip ROM (range of motion) and the Bent Knee Fall Out test values, stratified per age group (based on cross-sectional analysis).

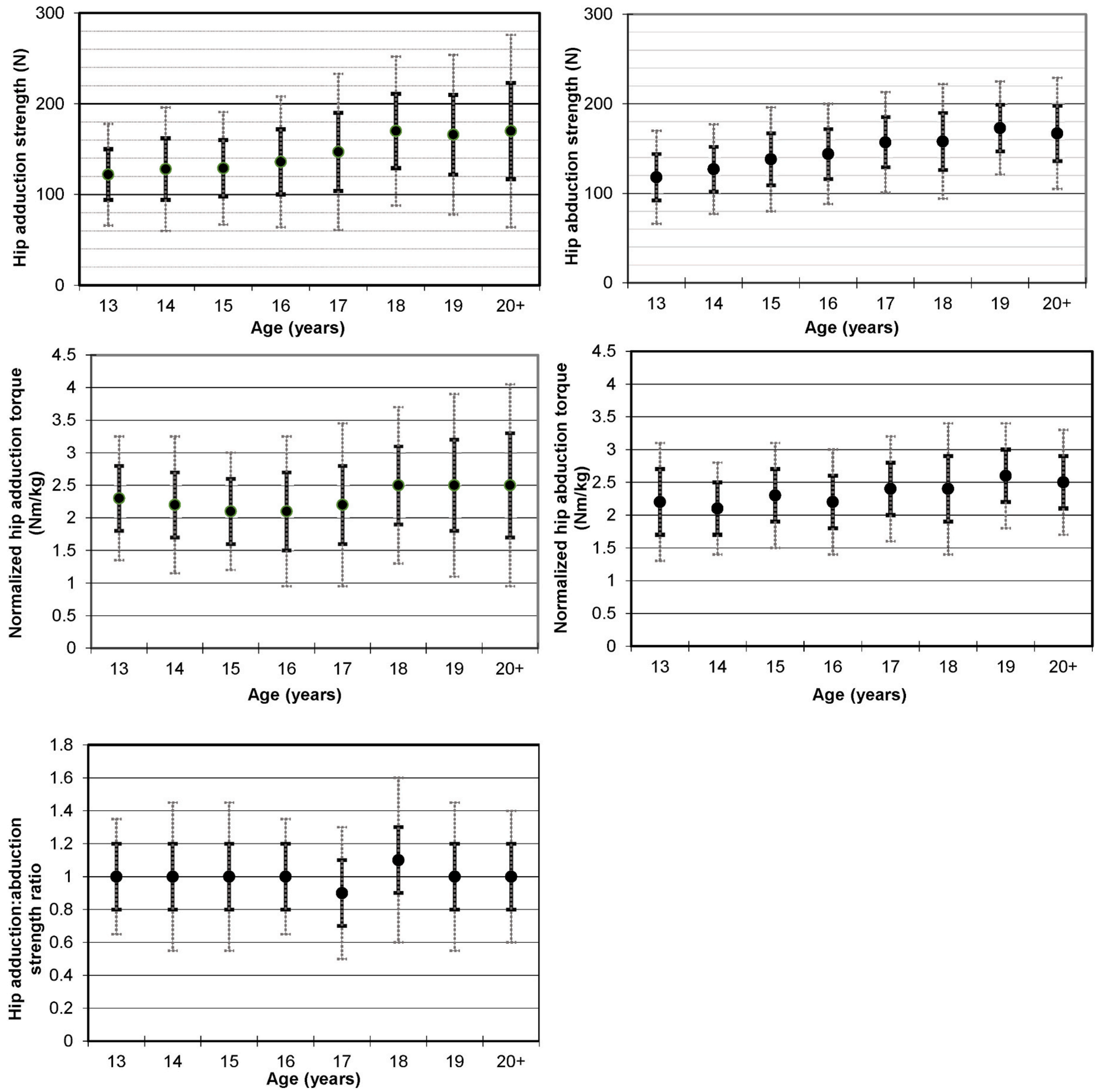

Fig. 3. Mean (●), 1 standard deviation (line) and 2 standard deviation (dotted line) values for peak hip adduction and abduction strength, torque values normalised for weight (Nm/kg), and the hip adduction:abduction strength ratio, stratified per age group (based on cross-sectional analysis).

external rotation. Age (β = -0.54, 95% CI: -0.89 to -0.19, p < 0.01) and BMI (β = -0.96, 95% CI: -1.48 to -0.44, p < 0.01) were also negatively associated with total hip range of motion. This means that older (adult) players seem to have a lower maximal hip external rotation (and in turn also a lower total hip range of motion) than younger (youth) players. We found no association between playing position (goal keeper vs field player) and hip internal rotation (p = 0.18), hip external rotation (p = 0.30), and total hip range of motion (p = 0.08). No differences were found for any range of motion test between the dominant and non-dominant leg.

8. Hip strength

Mean and SD values for hip adduction and abduction strength (N), normalised torque (Nm/kg), and the hip adduction:abduction strength ratio are presented in Table 1 and Fig. 3.

8.1. Linear mixed model analysis

Age (β = 4.7, 95% CI: 3.5–5.8, p < 0.001) and BMI (β = 4.3, 95% CI: 2.7–6.0, p < 0.001) were associated with peak hip adduction strength (N). Age (β = 0.05, 95% CI: 0.03–0.06, p < 0.001) was also associated with normalised hip adduction torque (Nm/kg). The β means that in our cohort, on average, the normalised hip adduction torque was 0.05 Nm/kg higher for each year players were older. Playing position (goal keeper vs field player) was not associated with peak hip adduction strength (p = 0.10) and normalised hip adduction torque (p = 0.51). Age (β = 3.6, 95% CI: 2.8–4.5, p < 0.001) and BMI (β = 5.4, 95% CI: 4.2–6.7, p < 0.001) were also associated with peak hip abduction strength. Age (β = 0.04, 95% CI: 0.02–0.05, p < 0.001) was also associated with normalised hip abduction torque. Playing position was not associated with peak hip abduction strength (p = 0.68) and normalised hip abduction torque (p = 0.39). There was no association between the hip adduction:abduction strength ratio and BMI (p = 0.07), age (p = 0.24) and playing position (p = 0.08). This means that older players demonstrated higher hip adduction and abduction strength values.

We found small statistically significant differences between the dominant and non-dominant hips for all strength tests, except for the hip adduction:abduction ratio (Appendix C). However, these differences were small (~1–2%) and within the measurement error and therefore probably not clinically relevant. Median asymmetry values between the left and right hip for all strength and ROM tests are presented in Appendix C.

9. Discussion

Our study based on 504 assessments provides normal values for hip strength and range of motion in elite youth and adult female football players. The absolute peak hip adduction and abduction strength was higher in adult players compared to youth players. Adult players had less hip external and total hip rotation compared to younger players. No clinically relevant differences were found between the dominant and non-dominant hip for both strength and range of motion measurements.

The adductor strength values found in our study are within the range found in previous studies investigating senior female athletes. In adult elite female Australian Football players (Mentiplay et al., 2019), a mean isometric hip adduction strength of ~147 N and a normalised hip adduction torque of 1.85Nm/kg was found, while a mean isometric hip adduction torque of 3.19–3.32Nm/kg (elite) and 2.40–2.42Nm/kg (sub-elite) was found in female Spanish football players (Jaenada-Carrilero, 2024). Similar differences were found for hip abduction strength. Differences between these strength values may be explained by differing testing methods: isometric hip adduction testing from supine position (Jaenada-Carrilero, 2024; Mentiplay et al., 2019) versus eccentric hip adduction testing from side-lying position in our study. The eccentric hip adduction strength ("break") test is often used clinically, as athletes with adductor-related groin pain often show large eccentric adductor strength deficits, while isometric strength testing do not show these deficits (Thorborg et al., 2014).

Previous studies evaluating hip strength development in female youth football mainly investigated hip abduction strength and found conflicting results. Two studies investigating hip abduction strength longitudinally in 12–14 year old (Quatman-Yates et al., 2013) and 14–16 year old (Nguyen et al., 2017) female football players reported a decrease (Quatman-Yates et al., 2013) and no change (Nguyen et al., 2017) in relative hip abduction strength, while another study found a significant increase in relative hip abduction strength between 10-14 and 15–19 year old athletes (Bittencourt et al., 2016). Studies investigating female (Fältström et al., 2022) and male (DeLang et al., 2020; Light et al., 2022) youth football players reported similar trends in the increase of (or larger) hip adduction and abduction strength as found in our study: while the absolute hip adduction and abduction strength (N) was larger in older players, differences were smaller (Fältström et al., 2022; Light et al., 2022) or absent (DeLang et al., 2020) when adjusted for leg length and body mass (i.e. normalised torque). In our study, the higher normalised hip adduction and abduction torque values found in older players were statistically significant, but differences were so small we feel it might not be clinically relevant. When using the reference values clinically in youth and adult football players, we recommend using normalised torque (Nm/kg) instead of absolute values (N) as leg length and body mass influences force output. Additionally, it seems that the variance (standard deviation) around the group mean for hip adduction strength is larger in female adult players compared to younger players, which can also be observed in male players (Light et al., 2022).

The hip adduction:abduction strength ratio found in our study is comparable to the mean ratio found in female Australian football players (1.0 ± 0.2) (Mentiplay et al., 2019) and male ice hockey players (0.95) (Tyler et al., 2001), but slightly lower than in male field hockey players (1.1 ± 0.1) (Beddows et al., 2020) and male professional football players (1.2±0.2 (Mosler et al., 2017) and ~1.6 (Light et al., 2022)). Jaenada-Carrilero et al. (Jaenada-Carrilero, 2024) reported a mean ratio of 1.1–1.2 in (sub-)elite female football players for isometric hip adduction/abduction strength measured from supine position. These differences in mean strength ratios highlight that risk profiles may differ between sports and genders, and that test positions may also influence this ratio.

The smaller rotational hip ROM in older players is a consistent finding in the literature (Manning & Hudson, 2009; Svenningsen et al., 1989). Hip ROM findings in our study were rounded and recorded to the closest 5°, which decreases accuracy and increases potential measurement error. A SEM of 3° for hip external range of motion results in a Minimal Detectable Change of 7° (i.e. the minimal amount of change that a measurement must show to be greater than measurement error or within person variability) (Tak et al., 2017). The smaller hip rotational ROM findings in older players found in our study are therefore likely within measurement error. The hip internal rotation found in our study for senior players is comparable to previous studies investigating female athletes (mean: 33–42°) (Czuppon et al., 2017; Hogg et al., 2018; Swärd Aminoff et al., 2022). Larger variations for hip external rotation were found in previous studies with varying means from 23 ± 7° in female cross-country athletes (Hogg et al., 2018) to 50 ± 10° in female college freshman athletes (Czuppon et al., 2017). Hip ROM values can differ between populations due to differing age (Manning & Hudson, 2009; Svenningsen et al., 1989), sports (Hogg et al., 2018; Manning & Hudson, 2009; Swärd Aminoff et al., 2022), measurement technique (hip in 90° flexion versus 0° flexion) (Mosler et al., 2017; Swärd Aminoff et al., 2022), BMI (Kouyoumdjian et al., 2012), gender (Czuppon et al., 2017; Hogg et al., 2018; Kouyoumdjian et al., 2012; Svenningsen et al., 1989; Swärd Aminoff et al., 2022), or the presence of bony morphology (Griffin et al., 2016). Rotational hip range of motion is larger in female athletes than in male athletes, with main differences found in hip internal rotation (Hogg et al., 2018; Swärd Aminoff et al., 2022). The clinical relevance of a smaller hip range of motion is part of an ongoing debate. A reduced hip internal range of motion is more often present in athletes with hip-and/or groin pain compared to athletes without hip and/or groin pain (Mosler et al., 2015). However, there is no strong evidence that screening for a smaller hip range of motion identifies athletes at risk for hip and/or groin pain (Tak et al., 2017).

Median asymmetry values of hip adduction- and abduction strength varied from 6 to 8%, with interquartile ranges varying from 3% to 12% for abduction strength, and 3%–14% for adduction strength. This means that 75% of asymptomatic players in our cohort showed asymmetry values up to 14%. Importantly, 25% of asymptomatic players showed difference larger than 14% for hip adduction strength. Traditionally, (arbitrary) cut-off scores of 10% or 15% are often used as a return to sports milestone after injuries such as hip adductor injuries (Nicholas & Tyler, 2002; Parkinson et al., 2021). Our findings show that strength asymmetry scores larger than 12–14% are common in female national team football players which challenges the commonly used cut-off of 10% in clinical practice (Nicholas & Tyler, 2002). We recommend using a 15% cut-off score rather than 10% (i.e. limb symmetry index of 85% over 90%) in clinical practice. Further research should evaluate if female football players who do not meet this cut-off score are more prone to hip and groin injuries.

Our study has several limitations. Strength- and range of motion measurements were performed by eight different sports medicine physicians. The inter-examiner reliability amongst these eight physicians was not evaluated, and we cannot exclude potential measurement error between examiners. Previous studies found an acceptable reliability for comparable strength- and range of motion measurements (Cibere et al., 2008; Krause et al., 2007; Mosler et al., 2017; Thorborg et al., 2009). Range of motion measurements were rounded to the closest 5° by the physician, which decreases the accuracy. The large sample size of our study may have compensated for this on a group level. We analysed and presented the normal values as (descriptive) cross-sectional data (Figs. 2 and 3; appendix A) as done in previous research (Beddows et al., 2020; Light et al., 2022; Mosler et al., 2017). This method did not account for potential within-player correlation for players who had multiple measurements. Other factors, such as a history of (hip/groin) injury may also have influenced hip strength and ROM values. One of the strengths of our study is the large sample size presenting normal values for hip strength- and range of motion for female football players across different ages. It is uncertain if our results can be extrapolated to other female athletic populations, such as female amateur football players.

There is a lack of sports medicine research among female athletes, despite the increasing professionalism across different sports (Emmonds et al., 2019). The results from our study can assist in the clinical assessment and management of female football players.

10. Conclusion

Normal values for hip strength and range of motion in youth and adult female national football players are presented that can be used as clinical reference values. Absolute hip adduction and abduction strength was higher in adult players than in youth players. Adult players had less hip external and total rotation than younger players, although the differences were small and likely within measurement error. No clinically relevant associations were observed between leg dominance, playing position and hip strength and ROM values.

Ethics approval statement

An ethics exemption was obtained from the Medical Ethics Review Committee of the Academic Medical Center, Amsterdam, The Netherlands (reference number W21_040 # 21.045)

CRediT authorship contribution statement

Willem M.P. Heijboer: Writing – original draft, Visualization, Methodology, Formal analysis, Conceptualization. **Karin M. Thijs:** Writing – review & editing, Methodology, Investigation, Data curation, Conceptualization. **Adam Weir:** Writing – review & editing, Supervision, Methodology, Conceptualization. **Andreas Serner:** Writing – review & editing, Supervision, Methodology, Conceptualization. **Johannes L. Tol:** Writing – review & editing, Supervision, Methodology, Conceptualization. **Edwin A. Goedhart:** Writing – review & editing, Methodology, Data curation, Conceptualization. **Floor P. Groot:** Writing – review & editing, Supervision, Methodology, Investigation, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ptsp.2024.06.005.

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