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Molecular & Cellular Biomechanics 2024, 21(1), 342.
https://doi.org/10.62617/mcb.v21i1.342

Article

Comparison of quadriceps and hamstring muscle strength ratios between dominant and non-dominant legs in Saudi under-17 and under-19 premier league football players: A cross-sectional study

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CITATION

Alhammad A, Ghulam H, Al Zaqrati I, et al. Comparison of quadriceps and hamstring muscle strength ratios between dominant and non-dominant legs in Saudi under-17 and under-19 premier league football players: A cross-sectional study. Molecular & Cellular Biomechanics. 2024; 21(1): 342. https://doi.org/10.62617/mcb.v21i1.342

ARTICLE INFO

Received: 9 September 2024
Accepted: 23 September 2024
Available online: 14 October 2024

Abstract: Football's global popularity is often overshadowed by frequent lower limb injuries, particularly hamstring strains, which are linked to imbalances in the strength ratio of hamstring-to-quadriceps (H/Q). Research on these factors among Saudi Premier League players, specifically in Madinah City, is limited. Our study is a cross-sectional study that assessed 42 male professional football players from Ohoud Football Club, divided into Underage 17 (UD- 17) and Under age 19 (UD-19) of age groups. The Strength of muscle for hamstrings and quadriceps, as well as the H/Q ratio, was measured using handheld dynamometers (HDD), and demographic data were analyzed using SPSSv26. Results showed that UD-19 players had significantly greater quadriceps strength on both dominants (dominant and non-dominant) sides compared to UD-17 players, with no significant differences in strength of hamstring. The ratio of hamstring to quadriceps was significantly higher in UD-17 players on the dominant side compared to UD-19 players, but statistically significant differences were not found on the non-dominant side. These results suggest that quadriceps strength develops with age and training, potentially reducing injury risk, while the strength of hamstring stabilizes earlier. Tailored training programs focusing on quadriceps strength and balanced hamstring development are recommended for improving injury prevention and performance. Future research involving larger and more diverse samples could further validate these findings and provide a deeper understanding of muscle dynamics in young football players.

Keywords: strength of muscle; H/Q ratio; football injuries; dominant side; age groups

1. Introduction

Football, the most popular sport in the world, unfortunately faces its share of injuries [1]. A 2020 study by the Gaelic League revealed that over 70% of football injuries were related to the legs and below hips, with hamstring injuries mentioned here 22% to 24% cases [2]. Another study covering the years 2001 to 2009 found that 31% of injuries in male football players were muscle- related, with hamstring injuries being the most frequent at 37%, while quadriceps injuries comprised 19% of total muscle damages [3]. In Asian Football, injury rates are comparable to those in Europe, but there is a notably higher incidence of ACL (anterior cruciate

ligament) ruptures and hamstring damages [4].

One significant risk factor for injuries, particularly hamstring damages and ACL injuries, is the set weakness of the hamstrings related to the quadriceps muscles [5,6]. This might occur If the ratio between Hamstring and quadriceps strength falls below 60% [7,8]. Additionally, professional football players who exhibit functional asymmetries are more susceptible to hamstring strains, indicating that an inter-limb asymmetry surpassing 10% or 15% heightens the likelihood of such injuries [4,5,9]. Also, it was established that addressing ratio imbalances led to a decrease in injuries during the in-season period and H/Q ratios are also employed in return-to-play (RTP) situations following an injury [10]. A study found that athletes showing significant differences in isokinetic knee flexor strength had a fivefold increase in the risk of hamstring injuries and that established that injuries were more likely to occur in individuals with strength imbalances compared to those without such imbalances, affecting both sides of the body [10]. Even after corrective training, the relative risk of injury remained significantly elevated at 4.66 for those with bilateral strength imbalances [10].

Our research study objective is to compare strength of muscle and the ratio of hamstring to quadriceps (H/O) between the dominant and non-dominant sides with young professional football players from two different age divisions in the Saudi Premier League, based in Madinah City.

2. Literature review

Football holds the title as the world's most widely embraced sport; however, it is inevitable that injuries occur in the sport despite its popularity [11,12]. The amalgamation of high-intensity situations, like jumping, landing, and tackling, along with frequent exposure to collisions and physical contact, markedly elevates the likelihood of sustaining injuries, compared to other sports [12–15]. A systematic review found that the injury incidence rates (IIRs) for both female and male youth football players, including overall, match, and training exposure, are greater compared to those reported in other studies examining various other youth team sports, handball, basketball and volleyball [16]. Also, it showed in a season, male youth football players had a 47% likelihood of experiencing a time-loss injury, while female players had a 43% probability of the same and very low injuries exhibited the highest injury incidence rates in comparison to injuries affecting other body regions [16,17]. Among young male football players, muscle strains and ligament sprains such as hamstring strains and ACL injuries (anterior cruciate ligament) are the widely again and again recorded in the types of injuries [17].

Hamstring and quadriceps muscle injuries are consistently diagnosed injuries frequently various injuries in both adult and youth football players [18–20]. A study conducted in Spain with elite young football players across four age categories (Senior, UD-19, UD-16, and UD-14) found that injuries of hamstring is the most frequent type of injury at all levels, with a particularly high prevalence among UD-19 and UD-16 players [20]. Another study examining sports-related injuries in Arab countries found that muscle strains were the most common type of injury in football, accounting for 34% of all injuries [21]. The thigh was reported as the most

frequently affected area, representing 33.3% of the total cases [21].

Numerous risk factors, both intrinsic and extrinsic, contribute to injuries in sports, with asymmetries or imbalances in the Functional Hamstring/Quadriceps relationship being particularly influential in the occurrence of muscle injuries [22]. The Hamstring and quadriceps muscle groups play crucial roles in sprinting and vertical jumping performance, similarly, the H/Q ratio holds significant importance [23]. Previous research suggests that H/Q ratios could predict knee overload, often due to inadequate recruitment of hamstrings as joint stabilizers [24–26]. Previous studies recommend a minimum hamstring-to-quadriceps strength ratio of 0.6, indicating that the hamstrings should be at least 60% as stronger as the quadriceps [24–26]. The H/Q ratio is deemed significant for preventing injuries, particularly concerning Anterior Cruciate Ligament (ACL) injuries, maintaining an equilibrium in the H/Q ratio is thought to mitigate excessive strain on the ACL and lower the likelihood of injury, particularly in professional footballers, where there's a demand for substantial strength and power, this demand encompasses various activities such as jumps, high-speed kicks, and sudden diversion [27,28]. H/Q ratios falling below either 45% or 60% have been used as cutoff points to detect muscle imbalances, which could substantially elevate the risk of hamstring injuries by over four times when compared to players with normal H/Q ratios [10]. In addition, in a longitudinal study that involved 687 professional football players, individuals exhibiting a low ratio of hamstring to quadriceps (H/Q) ratio were discovered to have a four to a five-fold higher susceptibility to hamstring injuries [10]. The hamstrings and quadriceps are essential for the dynamic stabilization of the knee joint [29,30]. Therefore, maintaining balance between these muscles is crucial for preventing injuries during athletic movements like jumping, pivoting, and cross-cutting [31].

Dynamometers are instruments employed for quantifying the strength of muscle and are recognized as the most objective method for strength assessment. Among the various types of dynamometers utilized for this purpose are isokinetic dynamometers, portable fixed dynamometers, and handheld dynamometers [32]. Isokinetic Dynamometers are frequently utilized in clinical settings to evaluate muscular strength and are considered the benchmark for examining both concentric (con) and eccentric (ecc) actions being the gold standard for measuring. They offer researchers a reliable assessment tool that covers various parameters such as joint movement, velocity, range of motion, and action [33]. However, they were not utilized in this study due to their unavailability. Handheld dynamometers are compact, portable tools utilized for evaluating strength of muscle, commonly employed in both clinical and research environments. In this study, handheld dynamometers were chosen for their cost-effectiveness, portability, and proven ability to deliver robust concurrent validity and excellent reliability in assessing the isometric strength of muscle [34–37]. Research has consistently highlighted the validity and reliability of handheld dynamometers. Instance, studies have demonstrated strong intra and inter-rater reliability for evaluating knee strength of extension in rehabilitation participants using these devices [38,39]. Inter-limb asymmetries, which involve comparing the performance between limbs, have received considerable attention in the research literature [40–44].

For Professional football players, variations in maximal strength between the quadriceps and hamstrings across limbs can indicate decreased muscle function and a higher risk in terms of injury [45]. Research indicates that sportsman with significant asymmetries, lower vertical jump performance, and reduced aerobic fitness are more susceptible to injuries [46]. Balanced strength between limbs is known to enhance football related skills, including jumping and change of direction [43–48]. Additionally, inter-limb asymmetries of around 10% are associated with decreased jump performance [49]. Hamstring and quadriceps injuries are very common in Premier League football, often leading to substantial time away from training and competition. An optimal ratio of Hamstring to Quadriceps (H/Q) is crucial for on-field performance and efficiency. Handheld dynamometers (HDDs) offer a reliable and cost-effective method for measuring strength of muscle and the H/Q ratio, making them suitable for both clinical and field use. However, there is limited research on using HDDs to assess inter-limb asymmetry and the ratio of H/Q, especially in differentiating dominant and non-dominant sides among different divisions of the Saudi Arabian Premier League. Thus, studying strength of muscle and the ratio of H/Q in UD-17 and UD-19 players in this league is essential.

3. Methodology

The study involved 42 male professional football players from Ohoud Football Club, with 19 players in the UD-19 category and 23 in the UD-17 category. Exclusion criteria included recent lower limb muscle injuries, persistent thigh or leg pain, and any observable abnormalities that could impair lower limb performance. Participants with comorbid conditions such as cardiovascular or respiratory issues were also excluded. Only those players who were in good health and met the club's performance standards were included in the study.

3.1. Procedure

The procedure began with handing the players information sheet and briefing the players about the study's objectives, its purpose, and the potential benefits they could derive from participation (Appendix A). Consent form (Appendix B) was then obtained from them before proceeding further. Before collecting testing data and demographic information, players underwent a standardized 8- minute warm-up session (**Figure 1**). This session included 14 different types of stretches, with each stretch lasting 20 seconds with no repetitions [50].

Subsequently, demographic information was gathered from the players. This included their regular height. Height was measured from head to toe using a vertical measurement technique, and body weight was recorded with a digital scale. The dominant side was identified based on the leg players preferred for kicking the ball [51].

Figure 1. The 8-minute warm-up session.

3.2. Muscle test

3.2.1. Quadriceps

Strength of muscle evaluation began with the quadriceps using a handheld dynamometer (**Figure 2**). Participants were positioned seated with their legs extended and hanging over the edge of the table and their knees flexed at 90°. They used their arms to hold onto the sides of the table to reduce discomfort in the back of the thigh. A small pad supported the lower part of the thigh, and a belt secured the thighs to the table to ensure stability. Additionally, a belt was fastened to the table leg to stabilize the dynamometer, which was placed 5cm above the distal end of the lateral malleolus. Participants are instructed to extend their knees fully and execute three maximal isometric contractions (**Figure 3**) [52–54].

Figure 2. Hand held dynamometer.

Figure 3. Strength of muscle (quadriceps) handheld dynamometer.

3.2.2. Hamstrings

For the hamstring assessment, participants remained seated at the table's edge in the same position as during the quadriceps evaluation. However, the HDD (handheld dynamometer) was placed behind the participant's leg, and the belt was fastened to a metal tube in front of them. Participants were instructed to exert maximum force by pulling their leg backward, as if trying to draw their foot beneath the table, Players completed three trials for both hamstring and quadriceps assessments, and mean of these trials was used for analysis (**Figure 4**) [53,54].

Figure 4. Strength of muscle of the hamstrings using a handheld dynamometer.

4. Statistical analysis

Data were collected directly at the football club and using IBM SPSS (ver.26) all those data variable has been analyzed. Basic Descriptive statistics, i.e., mean and standard deviation, were used to tabulated the sociodemographic data. To assess differences between variables, a *t*-test was employed. Statistical significance was determined with a threshold *p*-value set to be 0.05, meaning results were considered statistically significant if the p-value < 0.05.

5. Result

The study compared various metrics between age under 17 (UD-17) and age under 19 (UD-19) Football players. The average age was significantly different, with U17 players at 17.00 ± 0.30 years and U19 players at 18.95 ± 0.23 years, yielding a *t*-value of 23.75 and a *p*-value = 0.000. Found statistically significant difference not found in height, weight, or BMI between the groups. UD-17 players had a mean height of 173.70 ± 6.76 cm, while UD-19 players had a mean height of 175.32 ± 5.79 cm ($t = 0.824$, $p = 0.415$). The mean weight for UD-17 players was 61.52 ± 8.60 kg and for U19 players was 64.21 ± 6.09 kg ($t = 1.145$, $p = 0.259$). BMI values were 20.33 ± 2.01 for UD-17 and 20.88 ± 1.47 for UD-19 players ($t = 0.986$, $p = 0.330$). The sample consisted of 23 in U17 players (54.8%) and 19 in UD-19 players (45.2%). **Table 1** shows the summarized data.

Table 1. Characteristic sample data under 17 and under 19.

Particulars	Under 17 Mean ± SD	Under 19 Mean ± SD	*t* Value	*p* Value
Age—Years	17.00 ± 0.30	18.95 ± 0.23	23.75	0.000
Height (cm)	173.70 ± 6.76	175.32 ± 5.79	0.824	0.415
Weight (kg)	61.52 ± 8.60	64.21 ± 6.09	1.145	0.259
Body Mass Index	20.33 ± 2.01	20.88 ± 1.47	0.986	0.330
Participants	23 (54.8%)	19 (45.2%)	-	

Table 2 presents the comparison of muscle strength measurements between Under-19 (U-19) and Under-17 (U-17) football players. For the quadriceps strength in the dominant leg, U19 players had a mean of 625.23 ± 150.72, while UD-17 players had a mean of 480.78 ± 132.57, with a significant difference indicated by a *t*-value = 3.263 and a *p*-value = 0.002. For the non-dominant quadriceps, UD-19 players had a mean of 613.21 ± 147.35, compared to 486.48 ± 153.75 in UD-17 players, showing statistically significant difference with a *t*-value = 2.720 and *p*-value = 0.010. Strength of hamstring in the dominant leg showed a mean of 272.44 ± 49.50 for U19 and 245.70 ± 48.51 for UD-17 players, with no significant difference (t = 1.762, p = 0.086). For the non-dominant hamstring, UD-19 players had a mean of 257.28 ± 56.17, while U17 players had a mean of 231.09 ± 73.55, with no significant difference found (t = 1.275, p = 0.210).

Table 2. Comparing quadriceps muscles strength between two groups.

Particulars	Group	*N*	Mean ± SD	Std. Error Mean	Skewness	*t* Value	*p* Value
Quadriceps-Dominant	Under 19 Under 17	19 23	625.23 ± 150.72 480.78 ± 132.57	34.57 27.64	0.417 0.583	3.263	0.002
Quadriceps-Non-dominant	Under 19 Under 17	19 23	613.21 ± 147.35 486.48 ± 153.75	33.81 32.05	−0.107 0.813	2.720	0.010
Hamstring-Dominant	Under 19 Under 17	19 23	272.44 ± 49.50 245.70 ± 48.51	11.36 10.11	0.541 −0.167	1.762	0.086
Hamstring-Non-dominant	Under 19 Under 17	19 23	257.28 ± 56.17 231.09 ± 73.55	12.89 15.34	−0.742 1.634	1.275	0.210

The comparison of ratio of hamstring to quadriceps (H/Q) on the dominant side between the Under 17 and Under 19 groups is summarized as follows **Table 3**.

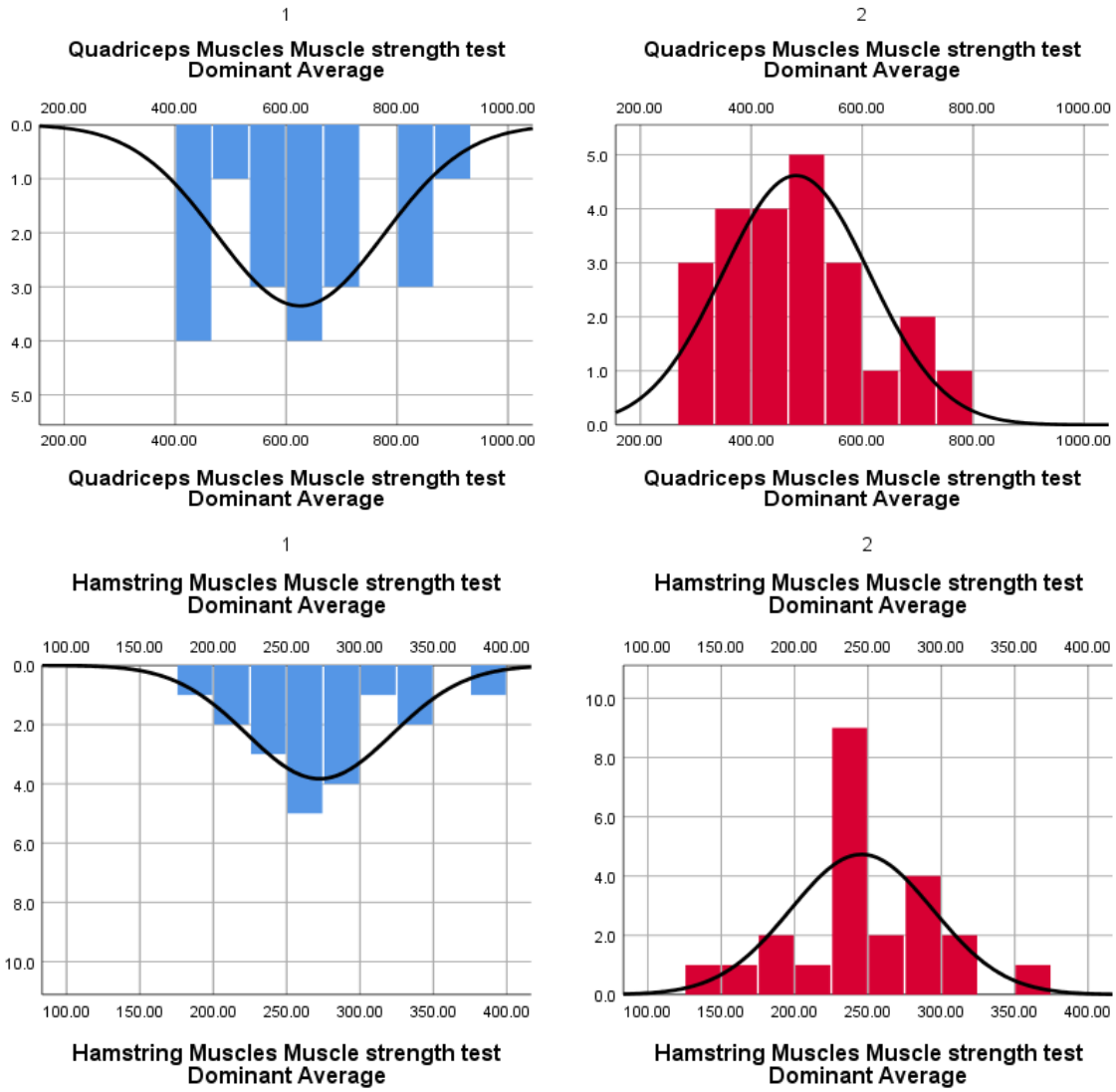
Table 3. Comparison ratio of H/Q dominant between two groups.

Particulars	Group	*N*	Mean ± SD (%)	Std. Error Mean (%)	Skewness	*t* Value	*p* Value
H/Q Ratio-Dominant	Under 19 Under 17	19 23	45.15 ± 9.87 53.91 ± 15.73	2.26 3.28	0.257 0.721	−2.198	0.031
H/Q Ratio-Non-dominant	Under 19 Under 17	19 23	43.59 ± 12.79 50.30 ± 17.12	2.94 3.57	1.605 0.777	−1.414	0.146

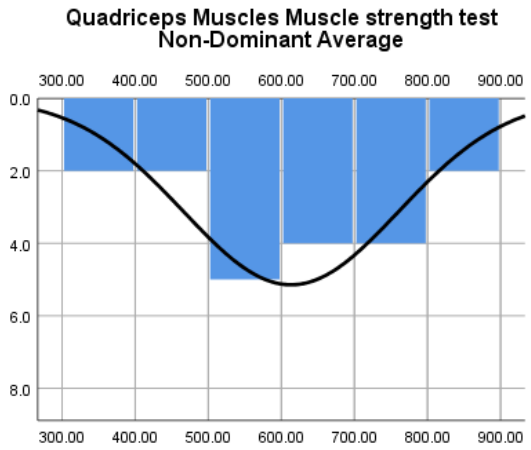
The study assessed the Hamstring to Quadriceps (H/Q) ratio between age under 19 (UD-19) and age under 17 (UD-17) football players. For the dominant leg, UD-19 players had an H/Q ratio of 45.15 ± 9.87%, while UD-17 players had a significantly higher ratio of 53.91 ± 15.73%, with a *t*- value = −2.198 and *p*-value =

0.031. In contrast, the H/Q ratio for the non-dominant leg was 43.59 ± 12.79% for U19 players and 50.30 ± 17.12% for UD-17 players. The difference between these ratios was not statistically significant, as indicated by a *t*-value = −1.414 and a *p*-value = 0.146. This suggests that the variation in ratio of H/Q for leg the non-dominant between the two age groups was not enough to be considered statistically meaningful.

The population pyramid illustrates the distribution of muscle strength for both dominant and non-dominant legs within the Under-17 and Under-19 groups. **Figure 5** presents various aspects of muscle strength, including average quadriceps and hamstring strength for both the dominant and non-dominant legs. Additionally, it includes an analysis of the hamstring-to-quadriceps (H/Q) ratio for both dominant and non-dominant legs. These graphical representations facilitate a comprehensive visual comparison between the two age groups. Each graph enhances the understanding of the differences in muscle strength profiles among the players.



1


Quadriceps Muscles Muscle strength test
Non-Dominant Average
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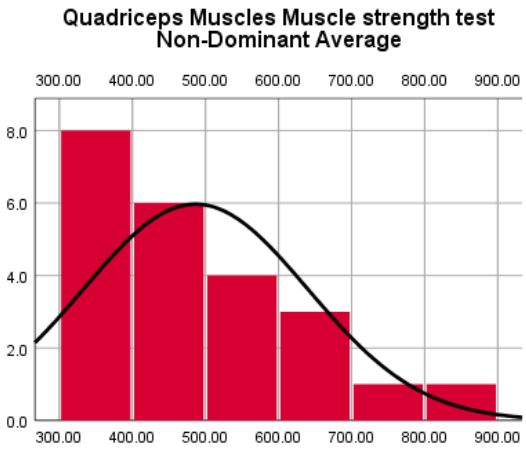
0.0 2.0 4.0 6.0 8.0

2


Quadriceps Muscles Muscle strength test
Non-Dominant Average
300.00 400.00 500.00 600.00 700.00 800.00 900.00
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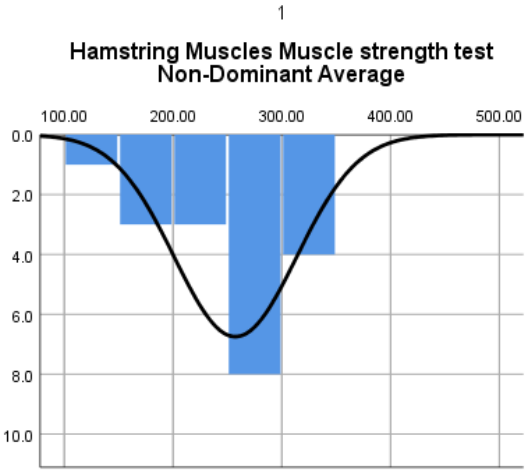
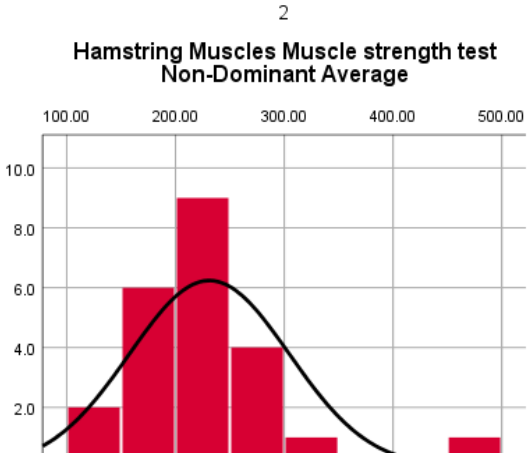
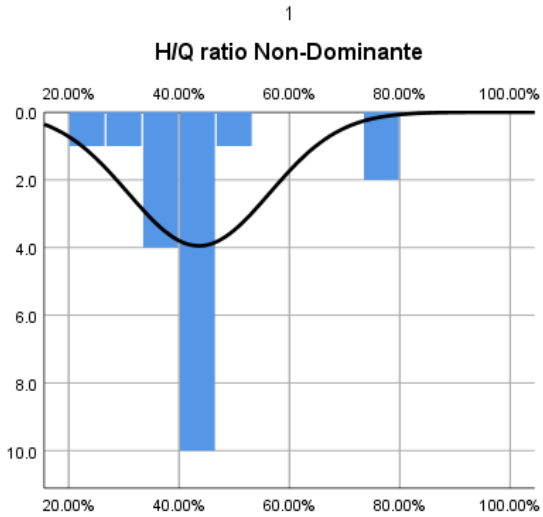
1


Hamstring Muscles Muscle strength test
Non-Dominant Average
100.00 200.00 300.00 400.00 500.00
0.0 2.0 4.0 6.0 8.0 10.0

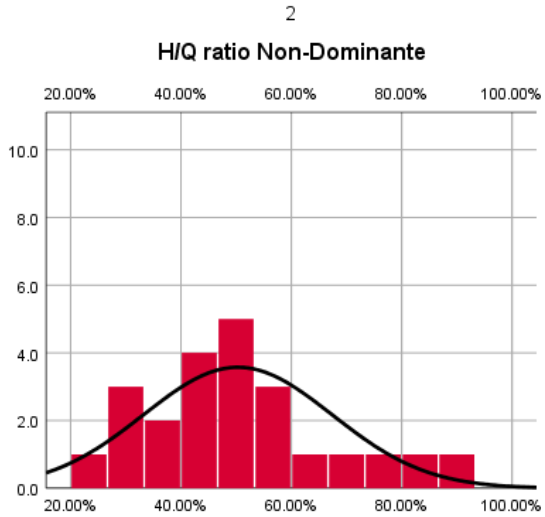
2


Hamstring Muscles Muscle strength test
Non-Dominant Average
100.00 200.00 300.00 400.00 500.00
0.0 2.0 4.0 6.0 8.0 10.0

1


H/Q ratio Non-Dominante
20.00% 40.00% 60.00% 80.00% 100.00%
0.0 2.0 4.0 6.0 8.0 10.0

2


H/Q ratio Non-Dominante
20.00% 40.00% 60.00% 80.00% 100.00%
0.0 2.0 4.0 6.0 8.0 10.0

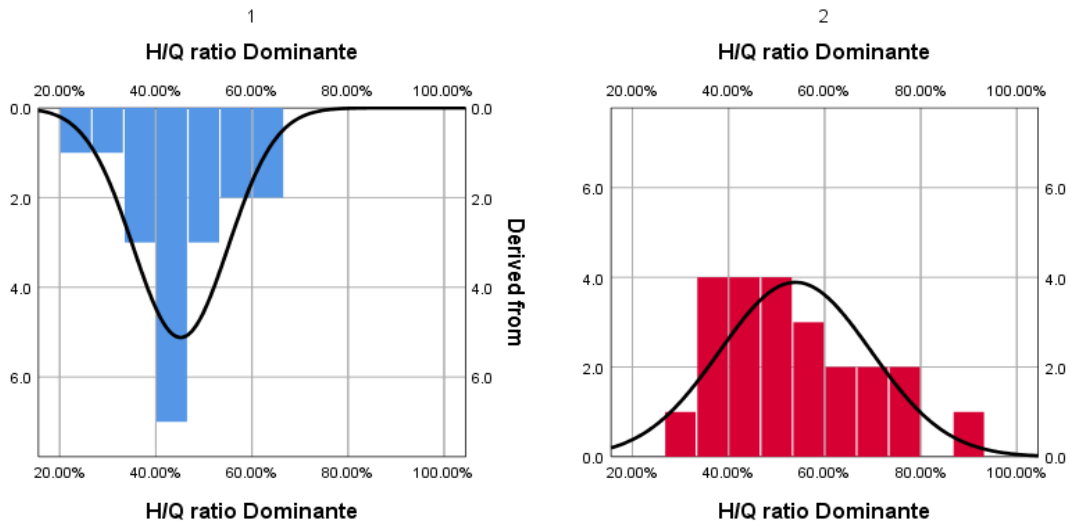


Figure 5. Population pyramid frequency quadriceps muscle strength, hamstring muscle strength and H/Q ratio, dominant and non-dominant.

These findings suggest a comparable H/Q ratio between adolescents under 17 and those under 19 on the non-dominant side. However, subtle discrepancies observed in the right non-dominant side may indicate nuances in muscle balance that could be explored in future studies.

6. Discussion

The study offered important insights into the muscle strength profiles and hamstring to quadriceps (H/Q) ratio of young football professional players in Madinah City, focusing on the Under-17 (UD-17) and Under-19 (UD-19) age groups. These findings are essential for developing specific strategies to prevent injuries and improve performance tailored to players in these age categories.

6.1. Age-related differences in quadriceps and hamstring strength

The comparison of quadriceps muscle strength between the UD-17 and UD-19 groups revealed significant age-related differences on the dominant and non-dominant sides. The UD-19 players exhibited significantly higher quadriceps strength compared to their UD-17 counterparts, both on the dominant and non-dominant sides. This finding aligns with previous research that highlights continued development of quadriceps strength during late adolescence due to age-related factors, growth, and increased training intensity. The development of quadriceps strength with age can enhance performance and reduce injury risks, as stronger quadriceps provide better support for the knee joint.

Interestingly, no significant age-related differences were observed in hamstring muscle strength between the groups, on either the dominant or non-dominant sides. This may indicate that hamstring strength plateaus earlier during adolescence or is less responsive to training stimuli at this age. Several studies have emphasized the importance of balancing the strength of agonist and antagonist muscle groups, particularly in football players. Imbalances, especially between the quadriceps and hamstrings, have been linked to a higher risk of injuries, such as hamstring strains or

anterior cruciate ligament (ACL) injuries [10,55,56].

6.2. Hamstring to quadriceps (H/Q) ratio and injury risk

Our results showed a significantly lower H/Q ratio in the dominant leg of UD-19 players compared to UD-17 players, indicating potential muscle imbalances. This imbalance may increase injury risk, particularly as football requires frequent explosive movements, accelerations, and decelerations that strain both muscle groups. A lower H/Q ratio is often associated with a higher likelihood of knee injuries, particularly ACL injuries, which are prevalent in football.

Contrary to our findings, a Danish study reported higher H/Q ratios in older adolescent players. This discrepancy may be due to population-specific differences, as environmental, genetic, and training factors can influence muscle development. Therefore, future studies should investigate the impact of geographical and cultural differences on muscle strength and injury risks in young athletes [10,57].

6.3. Implications of asymmetric developments

Asymmetries between the dominant and non-dominant legs, as observed in the H/Q ratios, support the notion that uneven muscle development could increase susceptibility to injuries, particularly in high-intensity sports like football. As players age, these asymmetries might become more pronounced, suggesting the need for targeted training interventions to address such imbalances. Corrective strength programs focusing on the hamstrings, specifically in the dominant leg, could help mitigate this risk and improve overall athletic performance.

6.4. Limitations and future directions

While our study provides valuable insights, several limitations must be acknowledged. The relatively small sample size limits the generalizability of the findings to a broader population of young football players. Additionally, our study focused exclusively on male players from a single football club in Madinah, which may not reflect the experiences of female players or those from different regions. Further, the use of handheld dynamometers, while convenient, may lack the precision of more advanced equipment like isokinetic dynamometers. Future research should include larger, more diverse samples and employ more precise measurement tools to validate these findings. Further research is needed to explore the underlying mechanisms behind these findings and their implications for injury prevention and performance improvement.

7. Conclusion

The study investigated strength of muscle characteristics and hamstring to quadriceps (H/Q) ratio among young professional football players in Madinah city, differentiating UD-17 and UD-19 age groups. Significant age-related differences were found in quadriceps strength, with UD-19 players demonstrating greater strength, particularly on the dominant and non-dominant side. However, statistically significant differences were not observed in strength of hamstring dominant and non-dominant side. Ratios of H/Q between the age groups showed a difference

by UD-17 showing a higher ratio than UD-19 on the dominant side with no difference in the non-dominant. These findings suggest that quadriceps strength continues to develop with age and training, potentially reducing injury risk, while strength of hamstring may stabilize earlier. Tailored training programs focusing on quadriceps strength and hamstring balance are recommended for injury prevention and performance optimization in young football players. Further research involving larger and more diverse samples should consider incorporating various methods of strength of muscle assessment to validate the findings and gain a more comprehensive understanding of strength of muscle characteristics in young footba1l players. This approach would help explore the underlying mechanisms and extend the findings to a broader population.

Author contributions: Conceptualization, AA (Ayman Alhammad) and HG; methodology, HA; software, AA (Ayman Alhammad); validation (Ayman Alhammad), HG and IAZ; formal analysis, AA (Ayman Alhammad); investigation, AA (Ayman Alhammad); resources, AA (Ayman Alhammad), AA (Abdulaziz Alsahli), AA (Abdulaziz Alhazmi) and IAZ; data curation, AA (Ayman Alhammad); writing—original draft preparation, AA (Ayman Alhammad); writing—review and editing, AA (Ayman Alhammad), AA (Abdulaziz Alsahli), AA (Abdulaziz Alhazmi) and OA; visualization, OA; supervision, AA (Ayman Alhammad); project administration, AA (Ayman Alhammad). All authors have read and agreed to the published version of the manuscript.

Conflict of interest: The authors declare no conflict of interest.

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Appendix A

Kingdom of Saudi Arabia
Ministry of Education
Taibah University
College Of Medical Rehabilitation Sciences
Physical Therapy Department

المملكة العربية السعودية
وزارة التعليم
جَامِعَة طيبة
كلية علوم التأهيل الطبي
قسم العلاج الطبيعي

Data Collection Sheet (.....)

Demographic Information:

Name	
Division	
Age	
Height	
Weight	
Height at 90	
Dominant Limb	

Muscle Strength Assessment (N):

	Trial 1	Trial 2	Trial 3	Average
Quadriceps - Dominant Limb				
Quadriceps - Non-dominant Limb				
Hamstrings - Dominant Limb				
Hamstrings - Non-dominant Limb				

Researcher's Signature: _____ ***Date:*** _____

Appendix B

Kingdom of Saudi Arabia
Ministry of Education
Taibah University
College Of Medical Rehabilitation Sciences
Physical Therapy Department

المملكة العربية السعودية
وزارة التعليم
جَامِعَة طيبة
كلية علوم التأهيل الطبي
قسم العلاج الطبيعي

نموذج طلب الموافقة للمشاركة في البحث

أنا .....، قد قرأت وفهمت المعلومات المقدمة في ورقة معلومات الدراسة بعنوان " تقييم قوة عضلات الفخذ الأمامية والخلفية وتأثير عدم توازن قوة العضلات على قدرة القفز للاعبي كرة القدم في الدوري السعودي الممتاز تحت ١٩ و ١٧ سنة".

لقد كان لدي الفرصة لطرح الأسئلة وتلقيت إجاباتٍ مرضية.
أفهم أن مشاركتي في هذه الدراسة هي طوعية، وأنني يمكنني الانسحاب في أي وقت دون أي عواقب سلبية.

أتعهد بتقديم جميع المعلومات المطلوبة بشكل دقيق وصحيح والمشاركة بصدق في الدراسة.
أفهم أن بياناتي ستُعالج بسرية تامة وستُستخدم فقط لأغراض البحث.

إنني أوافق على المشاركة في هذه الدراسة وفقًا للشروط المذكورة أعلاه.

تاريخ: التوقيع:

أنا الدكتور أيمن عبدالله الحماد، المسؤول عن هذه الدراسة، أؤكد أنني قد قمت بشرح المعلومات بشكل كامل. أنا متاح للرد على أي أسئلة أو استفسارات أو مخاوف قد تكون لديك على جوال 0504190818.

تاريخ: التوقيع: