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Exploring Positional and Age Variations in Hamstring Eccentric Strength in Academy Football Players

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Abstract

This study investigates the positional differences in hamstring eccentric strength among academy football players and its implications for performance and injury prevention. A cross-sectional design was employed, involving 125 male players aged 12-17 from a football academy in Turkey. Participants were categorized into six positional groups: forwards, midfielders, center-backs, full-backs, wingers, and goalkeepers. Eccentric hamstring strength was assessed using the iVMES H-BORD® device during Nordic hamstring exercises. The results indicated no statistically significant differences in hamstring eccentric strength across positions, though trends suggested that wingers and strikers exhibited higher maximal eccentric strength than defenders and goalkeepers. Additionally, older players (15-17 years) showed significantly higher hamstring strength than younger players (12-14 years), highlighting the importance of maturation and targeted strength training. While the findings emphasize the need for position-specific conditioning programs, the study's limitations include a small sample size and cross-sectional design. Further longitudinal research is recommended to explore the long-term effects of eccentric training and positional demands in youth football development. These results provide valuable insights for coaches and sports scientists to optimize injury prevention and performance enhancement in academy football.

Key Words: Hamstring, eccentric strength, football, positions, academy

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1. INTRODUCTION

Football is a high-intensity sport and requires sudden movements such as approximately 30 to 40 sprints, more than 700 changes of direction, 30 to 40 tackles, jumping, and rapid deceleration. These activities seriously pressure the musculoskeletal system, especially the hamstrings. Football has many injuries, most of which occur in the hamstring muscle region, which causes athletes to avoid training and competitions (Ekstrand, Hägglund, & Waldén, 2011). A study on English professional football athletes determined the thigh as the most common injury site and 81% of thigh injuries were classified as muscle strain (Woods et al., 2004). In the US Major League Soccer, hamstring strains occurring during matches and training accounted for 42% of all strain injuries (Morgan & Oberlander, 2001). In English professional football, 47% of hamstring strains occurred in the last 15 minutes of each half (Woods et al., 2004). Poor eccentric muscle strength is one of the primary etiological risk factors attributed to this high incidence. Academic research has revealed that weak eccentric knee flexors are consistently associated with a higher risk of hamstring strain injuries. Especially in elite athletes, inadequate eccentric strength is a significant risk factor for hamstring injuries (Bourne, Opar, Williams, & Shield, 2015; Timmins et al., 2016). Furthermore, short biceps femoris fascicles and poor eccentric strength are essential determinants of increased injury risk (Timmins et al., 2016) . As a result, eccentric hamstring strengthening has become a widely recommended injury prevention strategy to improve this specific type of strength, especially with exercises such as the Nordic hamstring curl (Opar, Williams, & Shield, 2012).

Some studies show that the training program contents of many football clubs competing in the Champions League, one of the world's top-level organizations, are not integrated with scientific research (Bahr, Thorborg, & Ekstrand, 2015). Although hamstring eccentric strength has been proven to reduce injuries and improve performance, sports teams cannot fully implement it in their training programs (Bahr et al., 2015). The differences between the practices in the field and scientific research suggest that the importance of hamstring strength should be considered. However, these programs should be shaped according to the needs of the athletes' positions (Mendiguchia, Alentorn-Geli, & Brughelli, 2012).

In football, the needs and positions of each position are different. When we evaluate the sprint parameter, we see that strikers and wing players frequently sprint and create eccentric loads on the hamstring muscles. On the other hand, defense and central midfield players create a load on the hamstring muscles during deceleration and acceleration movement patterns in many planes. In addition, athletes' endurance and strength outputs differ according to their positions (Bloomfield, Polman, & O'Donoghue, 2007; Di Salvo et al., 2007). The hamstring eccentric strength requirements of athletes at the youth level are essential, and it is thought that strength requirements may vary according to their positions. Studies examining hamstring eccentric strength values and positional differences in academy athletes must be more comprehensive. Our study investigates the differences in hamstring eccentric strength of Academy-level football players according to their positions and fills the gap in the literature.

By analyzing the eccentric strength profiles of players in different positions, we seek to identify positional differences that may contribute to the development of more specific and position-specific training interventions. Such information is essential for maximizing performance and reducing injury risk, especially for academy players at the developmental stage of their careers. Previous research has highlighted the importance of individualized training programs that consider the unique demands of each position (Arnason, Andersen, Holme, Engebretsen, & Bahr, 2008). Consequently, this study will provide valuable information about the role of hamstring eccentric strength in the position of footballers. As a result of the findings will help practitioners on the field, sports scientists, athletic trainers, and physiotherapists to design more effective training programs that meet the specific needs of players in different positions and ultimately contribute to improved performance and injury prevention in academy football.

2. METHODS

Study Design

This study employed a cross-sectional comparative design to evaluate and compare the eccentric hamstring strength of football players across different playing positions and categories.

Participants

The study includes 125 male academy football players, aged 12-17, from a football academy in Kütahya, Turkey. The players are divided into six positional groups: forwards, midfielders, center-backs, full-backs, wingers, and goalkeepers. Inclusion criteria require at least one year of organized football experience, no history of hamstring or ankle injuries in the past six months, and regular participation in team training sessions.

Study Ethics

This study was approved by the Scientific Research and Publication Ethics Committee of Kütahya Dumlupınar University on 2024/09 with document number 431.

Materials

To assess the hamstring eccentric strength have been used a specific dynamometer (iVMES H-BORD® Testing System, Ankara, Turkey) with software. This tool detects the strength expressed during the Nordic Hamstring exercise. This method provided reliable measurements to evaluate the strength of each athlete's hamstrings [Intraclass correlation coefficient (ICC)=0.90-097 (Akarçeşme et al., 2024). The equipment and procedure ensured consistent data collection across all participants. H-Bord specifications: Sampling Rate: 50 Hz (default)- 400 Hz, Capacity (per sensor): 1000 N / 100 kg, Safe Overload (per sensor): 1500 N / 150 kg, Maximum Overload (per sensor/2 sensors): 2000 N / 200 kg, Resolution: 1 N. The device provides maximal hamstring right and left force (newtons), torque (Nm), and maximal force asymmetries (Diff%).

Protocol

Before the evaluation all the participants followed a warm-up phase that was the same for everyone and included a low intensity self-paced cycling on an ergometer and lower limb exercises for a total duration of about 15 (10 min. cyling – 5 min. core and lower limb) minutes. Before the test, the Nordic Hamstring Exercise (NHE) was performed at submaximal intensity with 1 set of 3 repetitions to help participants understand and familiarize themselves with the movement. The Nordic Hamstring exercise protocols were conducted in eccentric mode, with a maximum of 3 eccentric movements per set. Full rest was provided between each repetition.

Players kneel on a padded board with each ankle secured just above the lateral malleolus by a padded hook equipped with a load cell. The knees are positioned so that the shanks are parallel to the floor, and the pull line of the hooks is precisely perpendicular to the ground. The hook arms are attached to a pivot that ensures force is always measured along the load cells' long axis. Players are instructed to lean forward as slowly as possible while maintaining a neutral trunk and hip posture with their hands crossed over their chest. Verbal encouragement is provided by a sports scientist to ensure maximal effort. The trial is considered acceptable if the force output reaches a clear peak, followed by a rapid decline when the player can no longer resist the gravitational pull on the segment above the knee joint.

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Each trial was recorded from the sagittal plane using a Canon XA35 camera at 50 Hz. The camera was positioned on a stand, fixed 3 meters away from the participant and at a height of 0.5 meters. All data were recorded using H-Bord software, and for each assessment, eccentric strength and lower limb strength asymmetry were measured (Figure 1).

Figure 1. Eccentric Hamstring Muscle Strength Test (H-Bord)

Statistical Analysis

The normality of the data was tested with the Shapiro-Wilk test. After determining that all data showed normal distribution, the one-way ANOVA test was used for statistical difference analysis. One-way ANOVA determined the differences in H-Bord parameters between ages and positions. Eta square values are reported for effect sizes. η^2 values between 0-0.009 were considered insignificant effect sizes, 0.01- 0.0588 as small effect sizes, 0.0589-0.1379 as medium effect sizes, and values greater than 0.1379 as large effect sizes. The significance level was set as $p \leq 0.05$ for all statistical tests. All data processing steps and analyses were performed using R programming language.

3.RESULTS

The values regarding the differences of H Bord values according to the positions are given in Table 1. There is no difference between the positions. When the differences in the parameters according to age were analyzed, it was found that all values differed between ages. Figure 2 shows the differences in the force of the left and Figure 3 the right Hamstring muscle according to age and position. Figure 4 shows the differences in the torque of the left and Figure 5 the right Hamstring muscle according to age and position. Figure 6 shows the differences in right and left foot maximal force according to age and position. The rain cloud plot shows the differences in the force of the left Hamstring muscle in Figure 7 and the right Hamstring muscle in Figure 8 according to age and position. The raincloud plot shows the differences in the torque of the left Hamstring muscle in Figure 9 and the right Hamstring muscle in Figure 10 according to age and position. In Figure 11, the differences in right and left foot maximal force according to age and position are shown by a raincloud plot.

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Table 1. One-Way ANOVA tables for positions differences

Parameters	Cases	df	Mean Square	F	p	η^2_p
Max Left	Positions	5	6284.420	1.600	0.165	0.063
	Residuals	119	3927.949			
Max Right	Positions	5	6547.855	1.771	0.124	0.069
	Residuals	119	3698.034			
Torque Left	Positions	5	2099.050	1.835	0.111	0.072
	Residuals	119	1143.934			
Torque Right	Positions	5	1515.891	1.179	0.324	0.047
	Residuals	119	1286.006			
Maximal Diff%	Positions	5	14.186	0.408	0.842	0.017
	Residuals	119	34.742			

Table 2. One-Way ANOVA tables for age differences

Parameters	Cases	df	Mean Square	F	p
Max Left	Age	5	40199.334	16.061	< .001
	Residuals	119	2502.953		
Max Right	Age	5	39797.622	17.296	< .001
	Residuals	119	2300.985		
Torque Left	Age	5	12705.185	18.195	< .001
	Residuals	119	698.298		
Torque Right	Age	5	12683.994	15.530	< .001
	Residuals	119	816.758		
Maximal Diff%	Age	5	34.533	1.019	0.410
	Residuals	119	33.887		

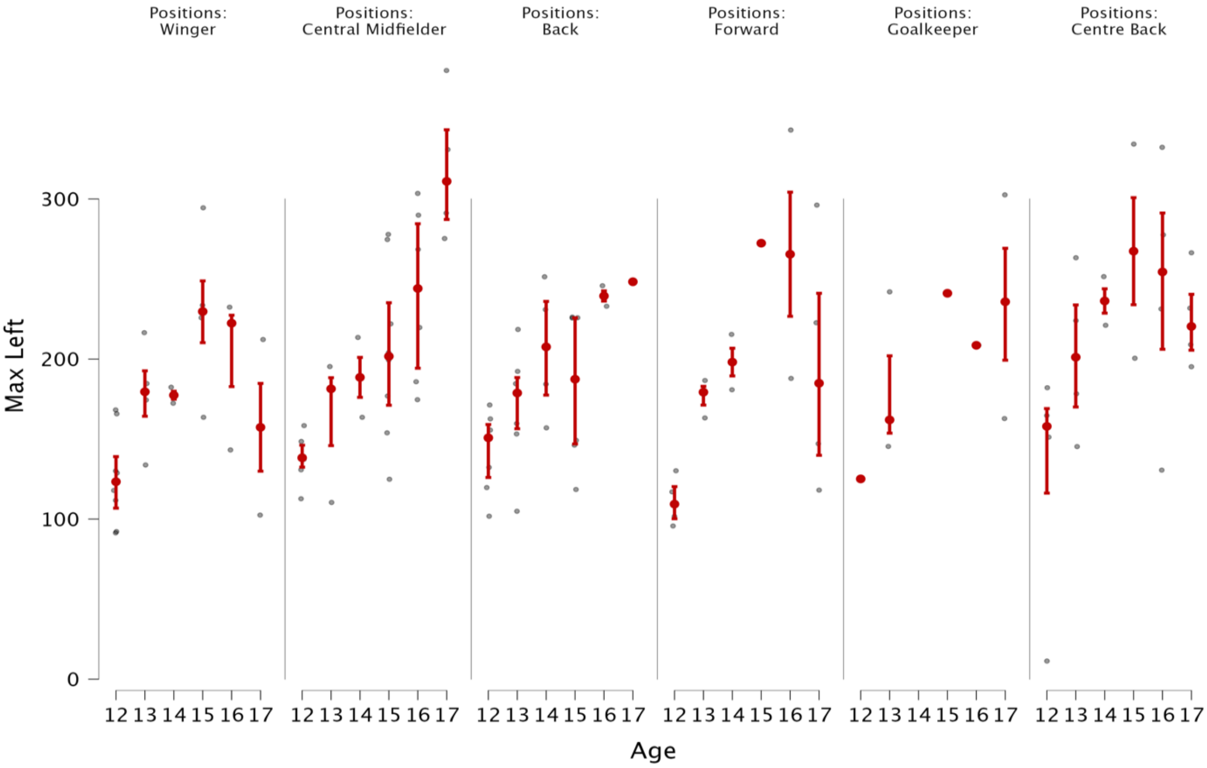

Figure 2. Left leg hamstring muscle maximum force (n) parameters for ages and positions

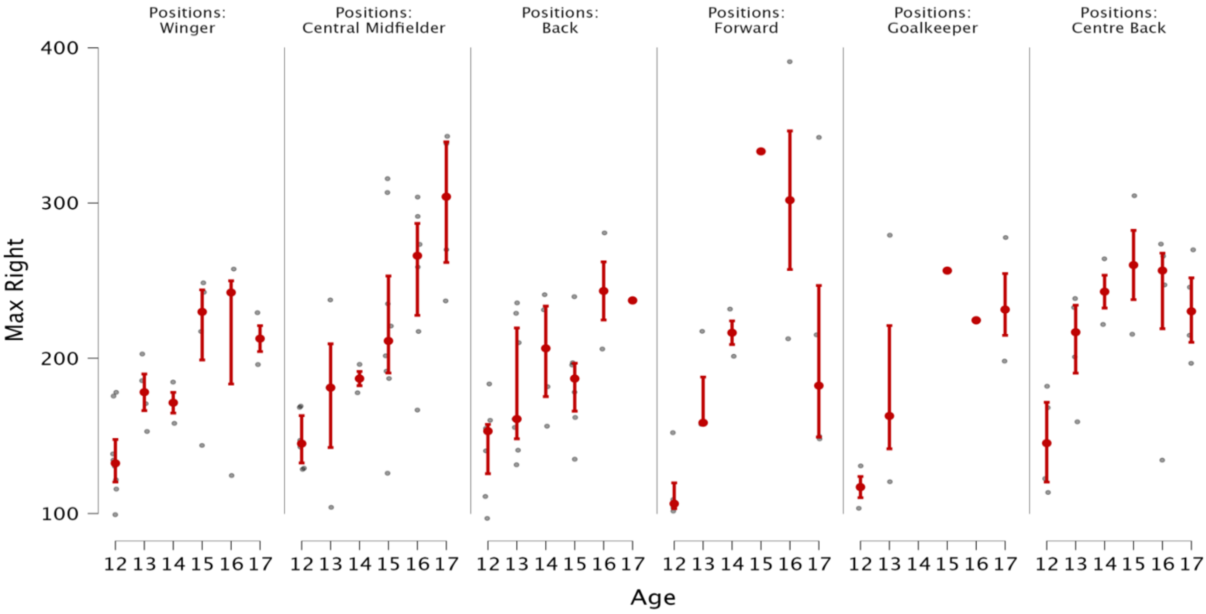

Figure 3. Right leg hamstring muscle maximum force (n) parameters for ages and positions

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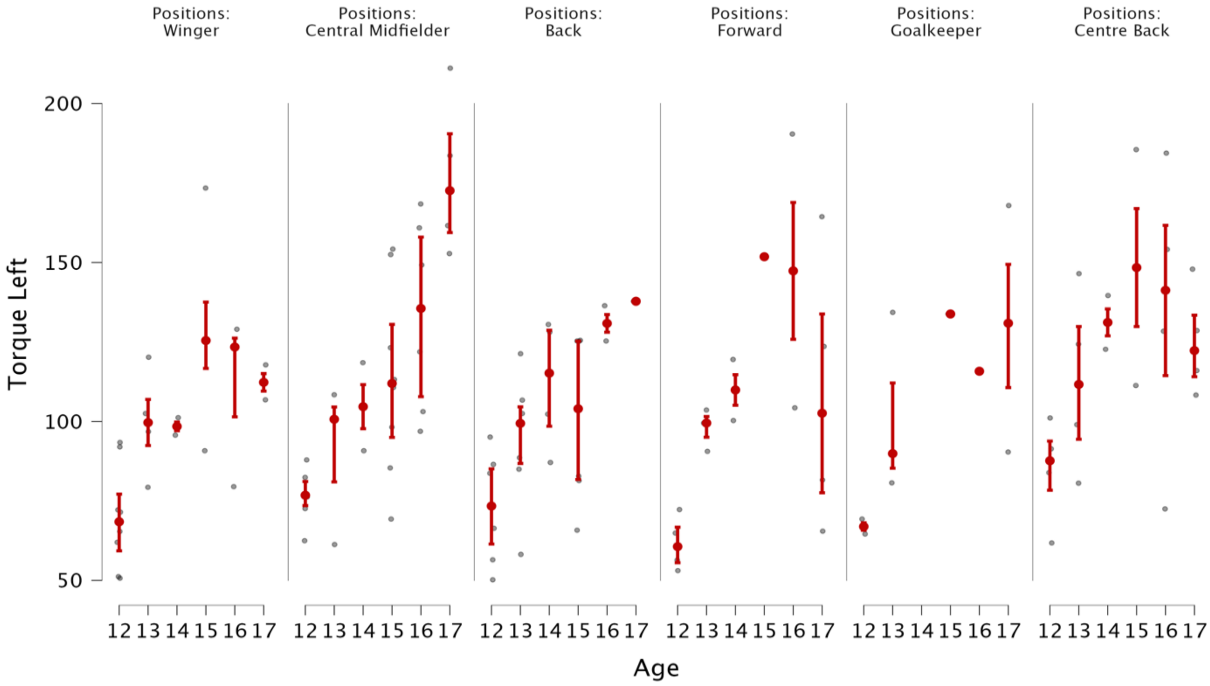

Figure 4. Left leg hamstring muscle torque (n) parameters for ages and positions

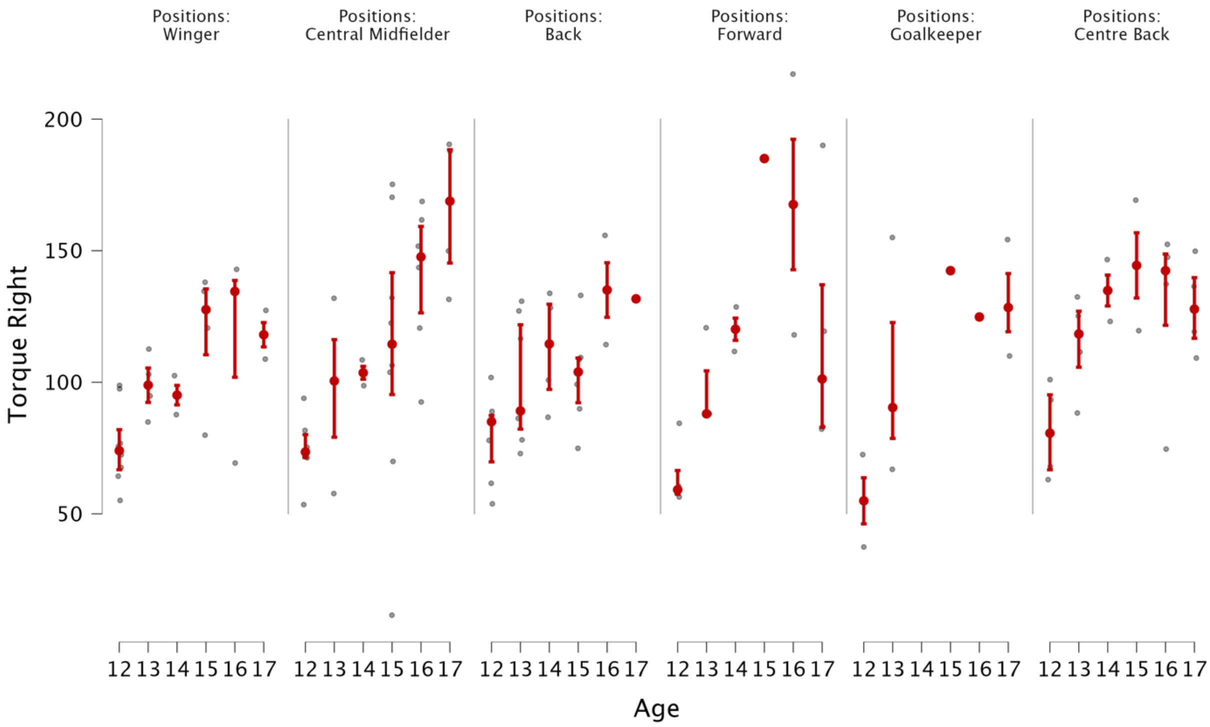

Figure 5. Right leg hamstring muscle torque (n) parameters for ages and positions

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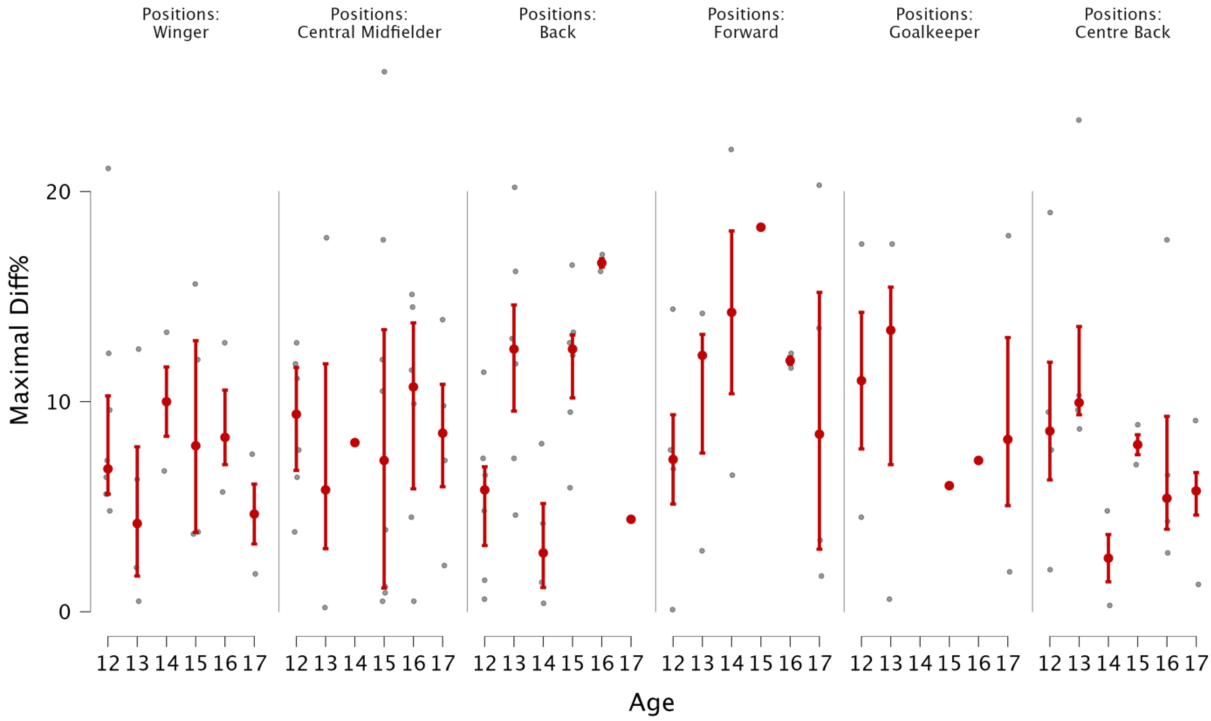

Figure 6. Hamstring muscle force(n) parameters difference (%) for ages and positions

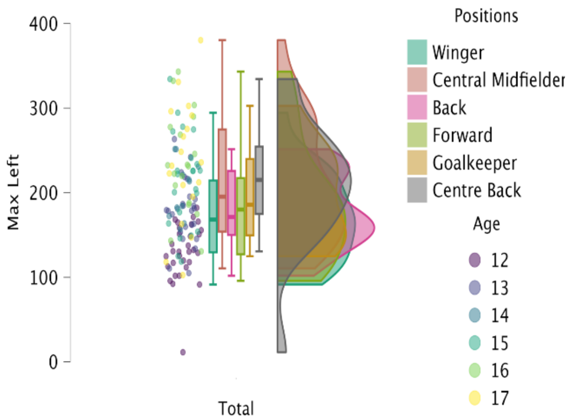

Figure 7. Raincloud plot of left leg hamstring muscle maximum force (N) parameters for ages and positions

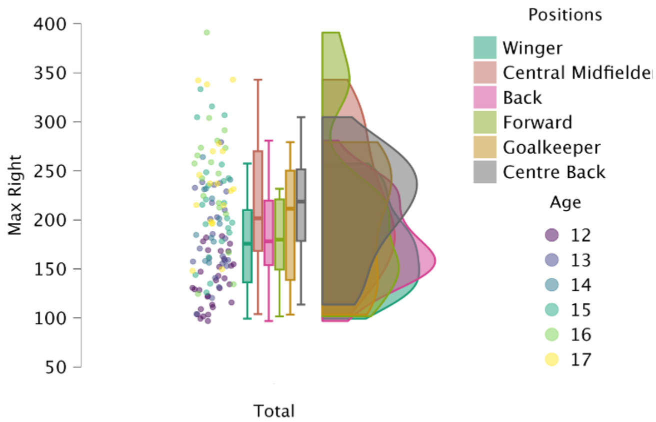

Figure 8. Raincloud plot of right leg hamstring muscle maximum force (N) parameters for ages and positions

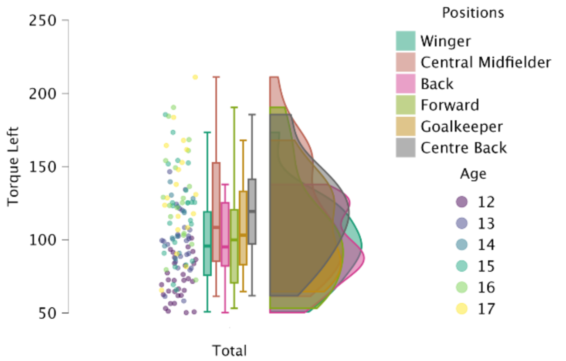

Figure 9. Raincloud plot of left leg hamstring muscle torque (nm) parameters for ages and positions

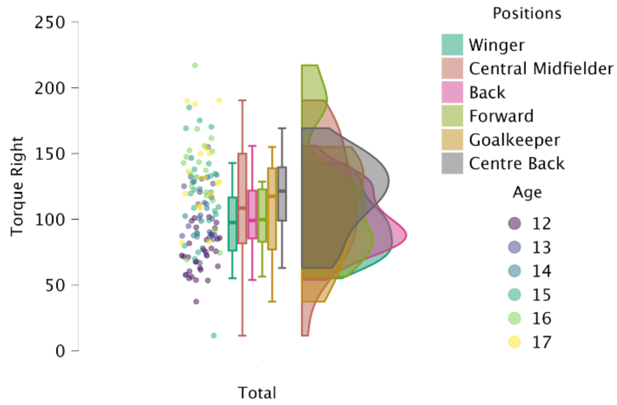

Figure 10. Raincloud plot of right leg hamstring muscle torque (nm) parameters for ages and positions

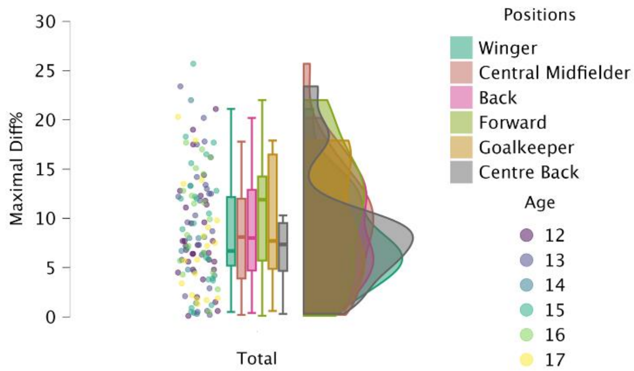

Figure 11. Hamstring muscle force (n) parameters difference (%) for ages and positions

4. DISCUSSION

The hamstrings play a crucial role during sports activities, particularly in sprinting, jumping, and leaping. Strong hamstring muscles can help generate greater power and force in these types of movements. In speed-demanding sports such as football hamstrings are essential for key movements like accelerations and decelerations (Chumanov, Heiderscheit, & Thelen, 2007; Morin et al., 2015).

The findings of this study offer valuable insights into the differences in eccentric hamstring strength among youth academy football players based on their playing positions, with significant implications for injury prevention and performance enhancement. Although the ANOVA results in Table 1 showed no statistically significant differences in eccentric hamstring strength among positions, distinct trends were evident. Wingers and strikers displayed higher maximal eccentric hamstring strength compared to goalkeepers and center-backs. This observation is consistent with previous research, which suggests that the high intensity running and sprinting demands of wingers and strikers necessitate greater hamstring strength (Di Salvo et al., 2007; Bloomfield et al., 2007). Based on these findings, coaches should consider adapting training programs to match the specific demands of each playing position. While center-backs and central midfielders frequently engage in deceleration and lateral movements, they displayed lower eccentric hamstring strength values. This aligns with research indicating that different positions in football require specific muscle adaptations (Śliwowski, Grygorowicz, Hojszyk, & Jadczak, 2017; Tourny-Chollet, Leroy, Léger, & Beuret-Blanquart, 2000). However, the lack of statistically significant findings may be attributed to limited sample size or individual variability in the technical and tactical roles within each position (Varley et al., 2017).

The differences between age groups highlighted in Table 2 reveal a clear relationship between age and eccentric hamstring strength development. Players in the older age group (15–17 years) exhibited significantly higher maximal eccentric hamstring strength than younger players (12–14 years). This is supported by previous studies showing that strength increases with biological maturation and exposure to advanced training regimens (Arnason et al., 2008). Ishøi et al. (2021) also observed increasing hamstring strength from U-13 to U-19, underscoring the importance of early strength training interventions in preparing young athletes for the high physical demands of elite competition (Ishøi et al., 2021). Furthermore, these age-related changes in hamstring strength appear critical for reducing injury risk, as older players face greater strength and conditioning demands in more competitive environments.

Eccentric hamstring strength values measured with the iVMES H-BORD® platform provide reliable, objective assessments of unilateral strength imbalances between the right and left hamstrings. As shown in Figure 1, this method facilitates a detailed evaluation of the maximal eccentric force and torque values for each leg. Detecting unilateral imbalances is crucial, as such asymmetries are known to elevate injury risk (Bourne et al., 2015). While the lack of significant differences in maximal percentage strength asymmetry between positions ($p = 0.842$) suggests that bilateral hamstring imbalances were relatively consistent across positions, even small asymmetries have been linked to increased injury rates (Timmins et al., 2016).

Though positional differences in this study were not statistically significant, the observed trends support the idea that football training programs should be tailored to address the eccentric strength demands of each position. For example, players in positions that require frequent sprinting, such as wingers and strikers, may benefit from more targeted eccentric hamstring training programs. Nordic hamstring exercises, shown to enhance eccentric strength and reduce injury risk, could be beneficial (Opar, Williams, & Shield, 2012).

This study highlights a gap in integrating scientific knowledge into the training programs of sports teams competing in the world's elite leagues, such as the Champions League As emphasized (Bahr et al., 2015). The reluctance of coaches to modify traditional training systems may stem from inadequate dissemination of innovative training programs, technological approaches, and current advancements to practitioners. The study's findings underscore the importance for practitioners, sports scientists, athletic performance coaches, physiotherapists, and sports science students to apply evidence-based practices, advocating for individualized and position-specific eccentric hamstring strengthening within athletes' training programs. Additionally, the implications of our research extend beyond injury risk prediction. Strong hamstring muscles support athletes in high-intensity activities such as sprinting, directional changes, acceleration, deceleration, and jumping during training and competition. Mendiguchia et al. (2012) report that position-specific and individualized exercise programs not only reduce athletes' injury risk but also contribute to performance enhancement (Mendiguchia et al., 2012).

Finally, alongside current scientific research, this study emphasizes the foundational role of eccentric hamstring exercises within strength training programs for football players. A unique and valuable aspect of this research is its focus on identifying hamstring differences based on player positions, providing important insights for the development of tailored training programs. Furthermore, the technologies used in this study are portable, lightweight, and user-friendly, making them suitable for use in fitness centers, football fields, and laboratories. Utilizing such reliable equipment enhances the accuracy of data collection

5. CONCLUSION AND RECOMMENDATIONS

This study highlights the importance of hamstring strength in academy football players competing in youth development leagues, analyzed based on age categories and playing positions. Although no statistically significant differences were observed in eccentric hamstring strength values across positions, the higher-intensity efforts required by players in attacking roles (forwards and wingers) indicate the necessity of position-specific adaptations in training programs. Furthermore, notable differences in age categories (U12-U17) suggest that lower extremity strength development, particularly in the hamstrings, plays a critical role during adolescence in enhancing performance and preventing injuries.

Eccentric strengthening exercises, such as the Nordic hamstring curl, remain a crucial injury prevention strategy, and their integration into football training programs should be encouraged. Advanced assessment tools like the iVMES H-BORD® system allow for more precise detection of strength imbalances and individualized program development.

Future research should focus on longitudinal studies to better understand how positional demands, training load, and injury risk evolve in youth football players. Additionally, efforts are needed to bridge the gap between scientific research and practical implementation in football training environments, ensuring that evidence-based practices are widely adopted to protect athletes and optimize their performance.

Author Contributions
All the authors equally contributed to the article.
Conflict of Interest
The authors declare any conflict of interest regarding the study and its publication.
Ethical Statement
University: Scientific Research and Publication Ethics Committee of Kütahya Dumlupınar University
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