Eccentric Hamstring Strength Imbalance among Football and Soccer Athletes

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Objectives: Hamstring strain injuries (HSI) are common among football and soccer athletes. Eccentric strength imbalance is considered a contributing factor for HSI. There is, however, a paucity of data on hamstring imbalances of soccer and American football athletes as they age and advance in skill level. High school athletes will display greater interlimb discrepancies compared with collegiate and professional athletes. In addition, soccer athletes will exhibit greater hamstring asymmetry than American football athletes.

Methods: Hamstring testing was performed on soccer and American football athletes using the NordBord Hamstring Testing System (Vald Performance, Albion, Australia). Age, sex, weight, sport specialization, and sport level were recorded. Maximum hamstring forces (N), torque (N · m), and work (N · s) were measured. Hamstring imbalance (%) was calculated by dividing the absolute value of the difference in leg forces divided by their sum. One-way analysis of variance and independent sample *t* tests compared measurements between athlete groups.

Results: A total of 631 athletes completed measurements, including 88 high school male soccer, 25 college male soccer, 23 professional male soccer, 83 high school female soccer, 28 college female soccer, 288 high school football, and 96 college football athletes. High school soccer players displayed significantly greater imbalances for torque ($P = 0.03$) and work ($P < 0.01$) than football athletes. Imbalances for maximum force ($P = 0.035$), torque ($P = 0.018$), and work ($P = 0.033$) were significantly higher for male soccer athletes in high school compared with college- and professional-level athletes. Female high school soccer players had significantly higher imbalance in torque ($P = 0.045$) and work ($P = 0.001$) compared with female collegiate soccer players. Football athletes did not experience significant changes in force imbalances between skill levels.

Conclusions: High school soccer athletes exhibit greater hamstring imbalances than football athletes. Higher levels of play in soccer, for both male and female athletes, correlate with less hamstring asymmetry.

Key Words: American football, athletics, eccentric hamstring strength, hamstring strain injuries, soccer

Hamstring strain injuries (HSIs) are common in football and soccer, affecting roughly 12% to 16% of athletes.[1–3] These injuries result in significant loss of time from play.[4,5] Moreover, even after rehabilitation, recurrence rates remain high and are reported to affect 14% to 34% of athletes with a prior injury and occur most commonly within the first month of resuming activities.[6–9]

The late swing phase of running, the time at which eccentric loading on the hamstring muscle is at its greatest, is the most common inciting action for HSI.[10–15] On the field, this translates to vulnerability during moments of rapid acceleration or deceleration, creating increased eccentric load and muscle strain during the late swing phase. As such, these injuries have been reported to disproportionately affect field position soccer athletes and certain American football players, including defensive backs and wide receivers.[6,16–18] A multitude of physiologic factors have been considered to contribute to HSI risk, including eccentric hamstring strength imbalances, low eccentric strength, torque,

Key Points

- At the high school level soccer athletes exhibit greater hamstring imbalances as well as hamstring strain injuries than football athletes at the high school level, suggestive of the role that eccentric hamstring strength can play in these injuries.
- Eccentric hamstring strength asymmetries are significant in high school soccer athletes when compared with college and professional athletes.
- Younger soccer athletes, especially high school females, exhibit significantly more interlimb work imbalances than their male soccer and football counterparts, placing them at risk for hamstring strain injuries.
- Single-sport high school athletes had significantly more work imbalances than multisport athletes.

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and muscular fatigue.[12,15,19–21] Force imbalances of >20% are associated with an increased risk for HSI.[19,20] Alterations in these metrics have been demonstrated to negatively influence body mechanics and resistance to injury-provoking stimuli.[22–26] Although there have been numerous studies evaluating hamstring physiology, biomechanics, and injuries in athletes, they are often limited to a single skill level (ie, youth or professional).

The present study investigated the interlimb differences in hamstring forces among soccer and American football athletes at various age and skill levels. Our aim was to evaluate the muscular imbalances in relation to sport, sex, skill level, and age. Our hypothesis is that soccer athletes will exhibit greater hamstring strength discrepancies. In addition, we suspect that such discrepancies will lessen with increased age and skill level.

Methods

Institutional review board approval was obtained before study enrollment. Local male and female high school and collegiate soccer players, male high school, and collegiate American football players, as well as professional male soccer athletes were consented and enrolled into the study during their respective preseason training in summer 2021. Participants were excluded if they were actively recovering from hamstring injury or underwent hip or lower extremity surgery within 1 year of study recruitment. Athlete age, sex, weight, primary sport (American football or soccer), participation in additional sports, skill level (high school, collegiate, professional), dominant leg, and history of hamstring injury in the past year were recorded.

Hamstring Force Measurements

Athlete hamstring strength was measured by performing the Nordic hamstring exercise test on the NordBord (Vald Performance, Albion, Australia). The NordBord is a device that can record the eccentric hamstring strength of an athlete based on the force placed upon a uniaxial load cell during descent in a Nordic curl.[27] Athletes were instructed to assume a kneeling position on the NordBord with their ankles secured by individual ankle braces attached to the uniaxial load cells. Participants were instructed to extend their chest and hips and position their hands in front of their chest. Once the proper posture was maintained, the athletes would eccentrically lower their body as slowly as possible to their maximum depth and catch themselves by bracing their hands against the ground (Fig. 1). After catching their fall, players returned themselves to the original upright position and repeated this action for a total of three measurements. If an athlete was observed to have improper form (flexing at the hip and/or back on descent), then the measurement was discarded and repeated. From these measurements, maximum force (N), torque (N · m), impulse (work, N · s) data for each leg was generated. Imbalances for each measure were calculated using previously published methods, whereby the absolute value of the difference in forces between contralateral legs was divided by the sum of leg forces[28,29] (Fig. 1).

Statistical Analysis

Data were analyzed using SPSS version 27 (IBM SPSS Statistics, Armonk, NY). One-way analysis of variance with least-significant difference post hoc testing was used to compare force imbalance values between athlete groups. The χ^2 tests were used to compare injury frequency between sports and levels, as well as the frequency of imbalance measures >20%, a previously published risk factor for HSI.[12,30] Pearson bivariate correlation was used to assess associations between imbalance measures and skill level, age, and weight. Statistical significance was set to $P < 0.05$.

Results

Demographics

A total of 632 athletes were surveyed and measured. The group comprised 459 high school (88 male soccer players from nine teams; 83 female soccer players from eight teams; 288 football players from seven teams), 149 collegiate (25 male soccer players, 28 female soccer players, and 96 football players from one university), and 24 professional (male soccer players from one team) athletes. Approximately 15% reported HSI in the previous year. Single-sport specialization was noted in 79.6% of high school soccer and 50% of high school football players (Table 1).

High School Athletes

Work imbalances were significantly more pronounced in single-sport high school athletes (single sport: 9.1% ± 10.3%,

A B

Fig. 1. **Starting position in the NordBord harness (A), with the athlete slowly leaning forward, resisting against gravity, with posture maintained (B).**

Table 1. Incidence of HSI

	High school			College			Professional
	Football	Male soccer	Female soccer	Football	Male soccer	Female soccer	Male soccer
N	288	88	83	96	25	28	24
Age	16.1 ± 1.4	16.3 ± 1.4	15.3 ± 1.2	21.4 ± 1.4	20.5 ± 1.5	20.0 ± 1.4	25.5 ± 4.7
Weight, kg	86.3 ± 24.4	67.3 ± 12.9	57.2 ± 10.1	105.1 ± 26.4	76.5 ± 7.6	61.0 ± 5.8	77.8 ± 8.8
Left/right leg dominance	36/252	8/80	7/76	8/88	7/18	3/25	4/20
Hamstring injury (%)	13 (4.5)	9 (10.2)	11 (13.3)	22 (22.9)	5 (20.0)	2 (7.1)	4 (16.7)
Multisport athletes (%)	145 (50.3)	15 (17.0)	20 (24.1)	—	—	—	—

HSI, hamstring strain injury.

multisport: 7.0% ± 6.5%; $P = 0.012$). A significantly higher rate of HSI was reported in soccer athletes (11.7%) compared with football athletes (4.5%; $P = 0.004$) (Table 1). High school soccer and football athletes did not demonstrate significantly different rates of >20% imbalance for maximum force (soccer: 14.6%, football: 10.8%; $P = 0.24$) (Table 2). Relative to high school football players, high school soccer players more frequently demonstrated >20% of muscular imbalances for torque (soccer: 4.1%, football: 1.0%; $P = 0.03$) and work (soccer: 15.2%, football: 5.9%; $P < 0.01$) (Table 2).

Between high school male and female soccer athletes, there were no significant differences in rates of >20% maximum force or torque imbalances. Female soccer athletes exhibited higher rates of >20% work imbalance than male soccer athletes ($P = 0.017$) (Fig. 2A).

College Athletes

There were no significant differences in maximum force, torque, or work imbalance between soccer and football collegiate athletes (Fig. 2B). In addition, the proportion of athletes with >20% interlimb imbalance of maximum force, torque, and work did not differ between collegiate soccer and football athletes (Table 2).

American Football Athletes

The proportion of athletes with >20% interlimb imbalance did not differ at the collegiate and high school football levels (Fig. 2A). There was no significant correlation in skill level, age, or weight with the degree of force imbalances in football athletes.

Male Soccer Athletes

Male soccer athletes demonstrated significantly less imbalance for maximum force, torque, and work at higher levels of play. The mean imbalance was significantly higher for high school male soccer athletes compared with professional male soccer athletes for maximum force (6.5% ± 7.5%, 3.7% ± 2.7%; $P = 0.018$), torque (6.5% ± 7.4%, 3.6% ± 2.7%; $P = 0.035$), and work (9.6% ± 10.7%, 5.4% ± 5.2%; $P = 0.033$) (Fig. 2B).

Female Soccer Athletes

Mean imbalance was significantly higher for high school female soccer athletes as compared with collegiate female soccer athletes for torque (6.9% ± 6.8%, 4.5% ± 5.1%; $P = 0.045$) and work (12.5% ± 11.4%, 6.5% ± 7.3%; $P = 0.001$) (Fig. 2B). Skill level was significantly correlated with work imbalances ($R = -0.239$, $P = 0.012$) and approached significance for imbalances for maximum force ($R = -0.176$; $P = 0.064$) and torque ($R = -0.161$; $P = 0.091$). Work imbalances also were negatively correlated with age ($R = -0.195$; $P = 0.040$) and weight ($R = -0.192$; $P = 0.043$).

Discussion

To our knowledge this is the first study to evaluate the differences in eccentric hamstring imbalances between soccer and American football athletes at various skill levels. Our most important finding is that high school soccer athletes exhibit greater hamstring imbalances than do football athletes. Higher levels of play in soccer, for both male and female athletes, correlate with less hamstring strength asymmetry.

Table 2. Incidence of >20% interlimb imbalance

	High school				College				Professional
>20% imbalance N (%)	Football	Male soccer	Female soccer	*P*	Football	Male soccer	Female soccer	*P*	Male soccer
Maximum force	31 (10.7)	11 (12.5)	14 (16.9)	0.24	8 (8.3)	3 (12.0)	2 (7.1)	0.90	0 (0)
Torque	3 (1.0)	2 (2.3)	5 (6.0)	0.03	2 (2.1)	0 (0.0)	1 (3.6)	0.89	0 (0)
Work	17 (5.9)	10 (11.4)	16 (19.3)	<0.01	3 (3.1)	1 (4.0)	4 (14.3)	0.13	0 (0)

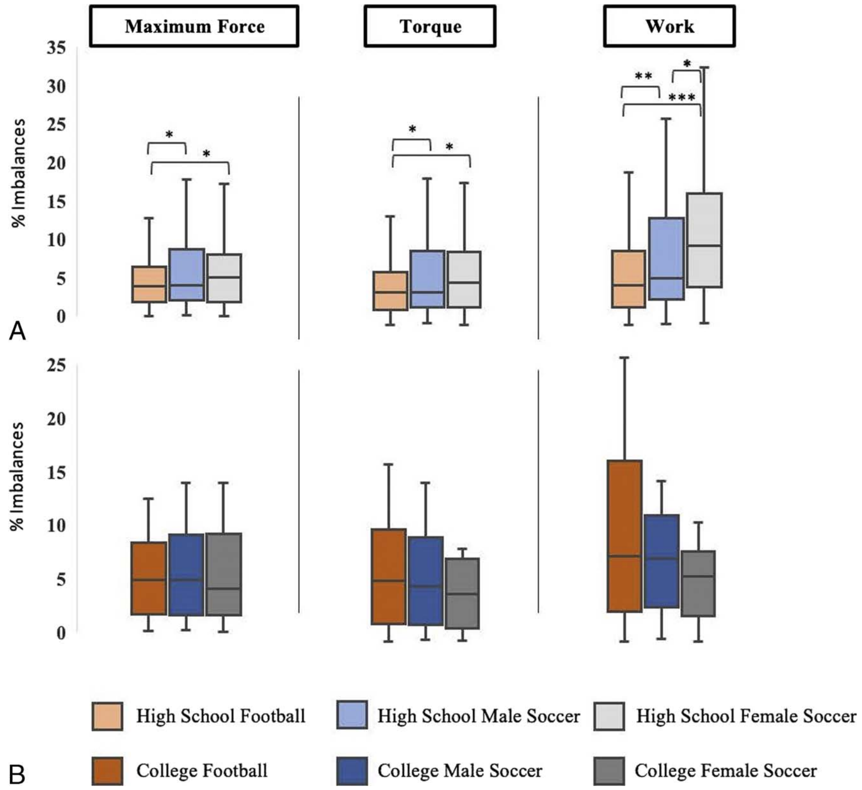

Fig. 2. Differences in hamstring imbalance between sports.

HSI is commonly caused by activities that rapidly eccentrically load the hamstring muscle such as sprinting, stopping, and cutting.[31,32] Positions for which these movements are common, wide receivers and defensive backs in football, and any field position in soccer, frequently succumb to HSIs.[6,16–18] Previous literature indicates that hamstring strength imbalances may contribute to HSI incidence.[19,20] As these athletes age, strength increases and muscle flexibility decreases.[33,34] We demonstrated that imbalances are more prevalent among younger athletes; however, data in young soccer athletes indicate a greater degree of hamstring flexibility, which may be injury protective.[33] These findings are consistent with prior reports that increasing age, despite decrease hamstring strength asymmetry with age, and hamstring stiffness are associated with hamstring injury.[35,36]

High school soccer athletes exhibited significantly greater hamstring asymmetry than high school American football athletes; however, the strength imbalances are less pronounced with increasing skill level. In this study, we demonstrate that high school soccer athletes exhibited significantly greater hamstring imbalances and a higher frequency of HSI as compared with American football players. Further attention should be directed at youth athletes, especially soccer athletes, in addressing hamstring imbalances. The discrepancies between high school soccer and football are likely attributed to differences in physiologic demands between sports, training regimens, and sport specialization, among other factors. As indicated by our data, muscle development (age and skill level) may be possible explanations because these factors are negatively correlated with imbalances. In our study, American football players were more balanced. In football, the emphasis on early enrollment in weight training regimens may help address muscular imbalances.

In addition to eccentric imbalance, muscular fatigue is a risk factor for HSI.[22,23] Fatigue-mediated reductions in muscle stiffness and eccentric strength diminish the capacity of a muscle to absorb energy and resist fascicle elongation, which can predispose athletes to injury.[22,23,26] In addition, hamstring fatigue can alter supporting muscular dynamics, promoting anterior pelvic tilt while sprinting, which lengthens, and thereby accentuates, eccentric muscle stress.[24,25,37] In our study, work imbalances, or the difference in maintained forces between legs, could be considered a surrogate for muscular fatigue and endurance because fatigue is characterized as the decline in physical performance resulting from exertion.[38] We demonstrate that younger soccer athletes, especially high school females, exhibit significantly more interlimb work imbalances than their male soccer and football counterparts. This difference may place them at an increased HSI risk. Although these discrepancies lessen with age, weight, and skill level, efforts to improve muscle strength balance and endurance are necessary. In addition, coaching and training staff should be mindful of athlete exertion and allow for adequate rest because nearly half of all soccer-related hamstring injuries are observed during the final 15 minutes of each half.[39]

With the growing interest in organized sports, single-sport specialization has grown in recent years.[40] Unfortunately, with the added hours of training and reduced rest periods between competition and practice, specialized athletes are experiencing higher rates of musculoskeletal injury and burnout compared with multisport athletes.[41–44] Furthermore, athletes who specialize in team sports, such as soccer or American football, are more likely to suffer from acute injuries such as HSIs.[43] Given the diversified physical demands of multisport athletes, one may infer that these athletes may exhibit less muscular asymmetry than specialized players. Although we did not demonstrate intrasport differences in imbalances related to specialization, we did note that overall, single sport high school athletes had significantly more work imbalances than multisport athletes. Also, interestingly, we found that collegiate American football athletes more frequently reported hamstring injuries than high school football athletes. This may reflect the intensive sport specialization and increased physical demands of collegiate football. With the high prevalence of muscular imbalance, especially among high school soccer athletes, additional strength training is likely indicated to improve muscular symmetry and reduce injury risk. Numerous hamstring exercises have been studied in regard to improving strength and imbalances, including single-leg deadlifts, single-leg Romanian chair holds, and Nordic curls.[41,45–47] In addition to enhancing hamstring strength and symmetry, the Nordic curl has been noted to improve resilience during high-velocity eccentric loading, improve strength, and promote faster and stronger fascicle recruitment.[30,41,45,47] Such beneficial findings likely explain the 50% to 70% risk reduction in initial injury and 85% risk reduction of reinjury following training protocols.[48,49] Nordic curls in addition to strength training may be protective against HSI in high school soccer athletes.

The present study is not without limitations. The activity leading up to force measurements was not controlled. Although measurements were collected before a training session, the level of activity leading up to the measurement was not recorded. Muscular imbalances were not stratified by field position because the study was not powered to detect such differences. Lastly, since this study is cross-sectional, we cannot conclude that increasing age and level of play lead to decreased hamstring imbalance.

Conclusions

High school soccer athletes exhibit greater hamstring imbalances than football athletes. Higher levels of play in soccer, for both male and female athletes, correlate with less hamstring strength asymmetry.

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