J. Phys. Ther. Sci. 31: 884–888, 2019

The Journal of Physical Therapy Science

Original Article

Side-to-side asymmetry in lower limb strength and hamstring-quadriceps strength ratio among collegiate American football players

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Abstract. [Purpose] The present study aimed to investigate the lower limbs injury risk factors that are based on conventional Hamstring to Quadriceps ratio and limb asymmetry index in varsity American football players. [Participants and Methods] Twenty-six varsity American football players aged 19–27 years and with 2.31 ± 1.29 years of American football experience from Dogu Akdeniz University volunteered to undergo measurements of average peak torque for isokinetic flexion and extension of dominant limb and non-dominant limb at $60°·s^{-1}$ and $300°·s^{-1}$. Hamstring to Quadriceps ratio and limb asymmetry index were also calculated for Hamstring and Quadriceps muscles. [Results] Statistical analysis revealed that dominant Quadriceps is stronger than non-dominant Quadriceps at $60°·s^{-1}$ speed. No statistical difference was found between dominant and non-dominant Hamstring peak torque at $60°·s^{-1}$. Hamstring to Quadriceps ratio determined as normal both for $60°·s^{-1}$ and $300°·s^{-1}$according to the currently reported cut off value (H:Q ratio >60). Hamstring and Quadriceps limb asymmetry index also determined as normal (cut off value for LSI 10%) at $60°·s^{-1}$. However, for both Hamstring and Quadriceps, side- to- side strength asymmetry at $300°·s^{-1}$ was observed. [Conclusion] To prevent possible lower limb injury and to increase performance, varsity American football players who are actively training and competing might consider taking strength asymmetry into account to tailor their strength training program accordingly.

Key words: Isokinetic testing, Limb asymmetry, American football players

(This article was submitted Mar. 5, 2019, and was accepted Aug. 7, 2019)

INTRODUCTION

Popularity of American Football (AF) is growing and reaching fans in more than a hundred countries[1, 2)]. This popularity of AF is attributed to playing characteristics which is primarily comprised of repeated maximum intensity bouts of the activity[3)]. The physical demands of the game include strength, speed, power, agility, flexibility as well as aerobic and anaerobic endurance[4)]. Playing characteristics of the AF is also argued to lead to high injury prevalence as it differs from other sports[5, 6)]. According to McGinity et al.[5)], severe and high injury rates are in nature of the sport of football. Due to high injury prevalence of the AF, participation has declined in recent years[5, 6)]. Factors lead to injury in sport are traditionally divided into two main categories; intrinsic (anatomy, anthropometry, body composition, skill level, muscle strength imbalance etc.) and extrinsic (sport equipment, weather conditions, floor-turf type etc.)[7)]. Lower limb strength, strength imbalance between Hamstring and Quadriceps muscles and strength imbalance between dominant and non-dominant limbs are considered very

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important in increasing performance and also preventing injury in AF[1].

Isokinetic dynamometry tests have been widely used and are the most common tools to assess Quadriceps and Hamstring muscle strength both in athletic and the non-athletic populations[8]. Isokinetic testing also provides the essential information about the Hamstring to Quadriceps ratio (H:Q) and limb asymmetry index (LSI) which can be used for evaluating lower limb muscle strength and imbalance between the muscles of the lower limb[9–12]. Although some researchers argued that LSI and H:Q are not good indicators of evaluating lower extremity performance and injury risk estimation factor[13–15], there have been several studies reporting different results[8, 11, 12].

Severo-Silveira et al.[1] reported that Brazilian AF players had Hamstring to Quadriceps strength imbalance and /or side to side strength asymmetry. On the other hand, Neophytou et al.[2] reported that elite male South African football players had a fairly good strength balance between the Hamstring and Quadriceps muscle groups when assessing the ipsilateral and bilateral H/Q ratio. Several risk factors for lower limbs injuries have been suggested, including non-modifiable ones such as age, previous injuries and ethnicity as well as modifiable factors such as strength, flexibility, and fatigue[7, 15]. Although research is controversial on the topic, side to side strength asymmetry, H:Q ratio with isokinetic strength testing are considered important factors for lower limb muscles injuries[7, 11, 15]. From this point of view, isokinetic testing was shown to be a relatively reliable tool for assessing the possible injury risk of players[11].

Therefore, the present study aimed to investigate the lower limbs injury risk factors in varsity American footballers, which are based on Hamstring to Quadriceps ratio and limb asymmetry index. We hypothesized that a) varsity AF players are exposed to side to side strength asymmetry in dominant and non-dominant limb in both $60°·s^{-1}$ and $300°·s^{-1}$, and b) muscle imbalance between Hamstring to Quadriceps in dominant and non-dominant limb in both $60°·s^{-1}$ and $300°·s^{-1}$.

PARTICIPANTS AND METHODS

Participants: Twenty-six varsity AF players aged 19–27 years, from Dogu Akdeniz University in Northern Cyprus participated in the study on a voluntary basis and signed an informed consent form. Ethical approval for this study was obtained from the ethics review committee of Eastern Mediterranean University (approval code: 2019/14-04). All of the players were right leg dominant. Inclusion criteria was determined as; a) should be >18 years old, b) minimum AF experience >1 year, c) actively playing collegiate football in University's football team d) no history of musculoskeletal, neurologic and cardiorespiratory complaints in the past 6 months. The players were instructed not to consume performance enhancing substances such as creatine, ribose etc. (coffee was limited to 1 cup) prior to tests, not to engage in high intensity physical activity 24 hours prior to the tests.

Body mass and height: Body mass and height measured by a body composition analyzer (Tanita MC-980 MA, Tokyo, Japan) and telescopic height measure scale (ADE, Hamburg, Germany).

Isokinetic testing: After a warm-up consisting of 10-min running on a motor-driven treadmill with self-selected speed (max speed limit: 6 km/h), participants were properly positioned in the isokinetic dynamometer HUMAC NORM Isokinetic Extremity System (CSMi, Stoughton, USA). Participants performed a set of five consecutive contraction of extension-flexion in concentric- concentric mode at $60°·s^{-1}$ and $300°·s^{-1}$. Participants performed two sub-maximal trials before performing five maximal efforts at each angular velocity. Each test separated with 2 min rest period. Participants were tested from low angular velocity to high angular velocity. Tests began with right leg and were completed with left leg. Participants were asked to perform maximal voluntary contractions bilaterally. To ensure maximal effort and contraction, players were also verbally encouraged throughout the testing. The highest peak torque value (N/m) obtained from each test was selected for statistical analysis.

LSI calculated by the formula[9]: Dominant leg peak torque − non-dominant leg peak torque/dominant leg peak torque × 100%.

H:Q ratio calculated by the formula[10]: Hamstring peak torque / Quadriceps peak torque

SPSS® (23.0 IBM) program was used for statistical analysis of the data. The normality of variables was checked by histograms and Shapiro-Wilk test. Paired Samples t-test was used to compare the pairwise comparisons of the related independent variables with normal distribution. The pairwise comparisons of the independent variables that did not show normal distribution was checked using the Wilcoxon Signed Ranks Test and descriptive statistics were reported as median (25/75 percentiles). All descriptive statistics were reported as absolute changes and statistical significance level was set at $p \leq 0.05$ for all analyses.

RESULTS

Descriptive characteristics of the AF players were presented in Table 1. Comparison between dominant (DOM) and non-dominant (ND) muscle peak torque at $60°·s^{-1}$ and at $300°·s^{-1}$ were given Tables 2 and 3, respectively. Data shown in Table 2 revealed that DOM Quadriceps is stronger than ND Quadriceps at $60°·s^{-1}$ speed ($p<0.05$). However, no statistical difference was found between DOM and ND Hamstring peak torque at $60°·s^{-1}$ ($p>0.05$). Furthermore, no statistical difference was found for Quadriceps and Hamstring peak torque between DOM and ND at $300°·s^{-1}$ ($p>0.05$) (Table 3). H:Q ratio determined as normal for both $60°·s^{-1}$ and $300°·s^{-1}$ according to currently reported cut off value (H:Q ratio>60) (Table 4).

Table 1. Descriptive characteristics of the American Football players

Variables	Mean ± SD
Age (years)	22.1 ± 2.1
Body mass (kg)	90.9 ± 14.2
Height (cm)	181.5 ± 3.8
AF experience (years)	2.3 ± 1.3

SD: Standard deviation.

Table 2. Comparison between dominant and non-dominant muscle peak torque at $60°\cdot s^{-1}$

	Mean ± SD (DOM)	Mean ± SD (ND)	Difference Mean ± SD
Quadriceps	258.4 ± 58.0	235.2 ± 58.1	23.3 ± 40.2*
Hamstring	153.4 ± 29.7	145.9 ± 37.9	7.4 ± 25.7

DOM: Dominant leg (right); ND: Non-dominant leg (left); SD: Standard deviation. * $p \leq 0.05$.

Table 3. Comparison between dominant and non-dominant muscles peak torque at $300°\cdot s^{-1}$

	Mean ± SD (DOM)	Mean ± SD (ND)	Difference Mean ± SD
Quadriceps	92.4 ± 29.6	97.8 ± 24.4	5.4 ± 27.2
Hamstring	72.5 ± 25.6	74.0 ± 23.3	1.6 ± 23.9

DOM: Dominant leg (right); ND: Non-dominant leg (left); SD: Standard deviation.

Table 4. Limb asymmetry index (LSI) and Hamstring to Quadriceps ratio (H:Q)

Velocity	H:Q		LSI	
	Mean ± SD (DOM)	Mean ± SD (ND)	Mean ± SD Quadriceps (%)	Mean ± SD Hamstring (%)
$60°\cdot s^{-1}$	60.7 ± 14.6	62.8 ± 13.5	7.5 ± 15.4	4.3 ± 18.9
$300°\cdot s^{-1}$	^{M}67.5 [11.00–99.00]	^{M}74.00 [10.00–99.00]	−15.6 ± 38.5*	−15.5 ± 57.2*

DOM: Dominant leg (right); ND: Non-dominant leg (left); SD: Standard deviation; H: Hamstring; Q: Quadriceps; LSI: Limb asymmetry index. Descriptive statistics are demonstrated as Median [25/75 percentiles] for nonparametric data. * LSI>10% or *LSI: negative numbers.

Although both Hamstring and Quadriceps limb asymmetry index determined as normal (cut off value for LSI 10%) between DOM and ND limb at $60°\cdot s^{-1}$, there was a side to side strength asymmetry at $300°\cdot s^{-1}$ for both Hamstrings and Quadriceps when cut off value for LSI accepted as 10% (Table 4). Negatives numbers for both Hamstrings and Quadriceps LSI values indicate side to side strength asymmetry as shown in Table 4.

DISCUSSION

The present study aimed to investigate the lower limbs injury risk factors in varsity American football players which are based on Hamstring to Quadriceps ratio and limb asymmetry index. The main finding of the study is that; varsity AF players had good muscle strength balance except for Hamstring and Quadriceps side to side strength at $300°\cdot s^{-1}$ and DOM Quadriceps being stronger than ND Quadriceps at $60°\cdot s^{-1}$ speed. The present study hypothesized that a) varsity AF players are prone to side to side strength asymmetry in DOM and ND limb in both $60°\cdot s^{-1}$ and $300°\cdot s^{-1}$, and b) there are muscle imbalances between Hamstring to Quadriceps in DOM and ND limb in both $60°\cdot s^{-1}$ and $300°\cdot s^{-1}$. According to results of the study, both of hypotheses were verified partially.

In sport and exercise science literature, there are no consensus for cut off values for LSI and conventional H:Q. According to Dauty et al.[16] and Croisier et al.[17], conventional H:Q cut off value should be >0.47. On the other hand, there are studies arguing that side to side strength difference should be less than 10%[18, 19]. Although there is no consensus regarding the reference values, this study considered cut off values of 60% for conventional H:Q ratio and 10% for LSI[18]. Very few studies tried to explain the relationship between strength asymmetry and injury risk in AF players in a study[11], where side to side strength asymmetry is accepted as 10%, 1,252 elite collegiate AF players (aged 20–27) were examined and it was reported that more than half of players had DOM and ND Quadriceps difference greater than ± 10% and 43% of players had Hamstring differences greater than ± 10%[11]. In the same study, AF players' ages and experience were similar to the players in our study therefore, H:Q and LSI cut off values were considered as >60 and 10% respectively for evaluating the results of our study as well.

Dervisevic and Hadzic[12] reported that possible strength asymmetry is best observed at low concentric velocities (e.g. $60°·s^{−1}$). The results of this study partially confirm the suggestion of Dervisevic and Hadzic[12], as DOM Quadriceps was found to be stronger than ND at $60°·s^{−1}$. It is known that isokinetic peak force tested at low velocities (e.g. 0–$180°·s^{−1}$), reflects pure muscle strength, while neuromuscular control comes into play at higher speeds (>$180°·s^{−1}$)[10]. This might possibly be the reason for the strength asymmetry at higher speed that occurred (>$180°·s^{−1}$) in our study ($300°·s^{−1}$) as well when LSI accepted as 10% (Table 4). If we consider that most functional sport specific activities occur at more than 300 $°·s^{-1}$ [20], isokinetic testing at higher speeds might be more functional than isokinetic testing at low speeds (<180°/sec).

Severo-Silveira et al.[1] reported that the 76–83% of elite Brazilian AF players represent conventional H:Q ratio less than 60%. In Brazilian AF players, side to side strength asymmetry greater than 10% was verified as 26% and 43% for Quadriceps and Hamstring muscles, respectively in contrast to the studies of Zvijac et al.[11] and Severo-Silveira et al[1]. In our study, only Quadriceps and Hamstring side to side strength asymmetry at $300°·s^{−1}$ with ratios −15.60 ± 38.52 and −15.48 ± 57.19 were found. At that angular speed, ND Hamstring and ND Quadriceps were able to produce more force than their respective dominant side.

Different results between Severo-Silveira et al.[1], Zvijac et al.[11] and this study might be related to training experience of the players as well. Players in our study had 2.31 ± 1.29 year experience with AF. Zvijac et al.[11] reported that limb asymmetry is not uncommon in first-year professional AF players. We think that these different results might be caused by factors such as; training status, experience level of AF the players, angular velocities used during testing, testing mode (concentric, isometric, isokinetic muscle contractions), cut off scores accepted for interpreting results, preferred limb (dominant, non-dominant, or both), the staffs' experience who will be operating the dynamometer etc. A single factor or combination of these variables might potentially cause different results. Therefore, compared to the previous studies, statistically significant differences as well as not significant differences obtained from this study might be associated with these factors.

This study has also some limitations. We have tested varsity AF players to peak torque, conventional H:Q and LSI index concentrically. However, eccentric measurements of functional H:Q and DOM and ND limb muscles might also lead to different result. Furthermore, we examined our results according to LSI 10% and conventional H:Q 60%. If LSI 15% and H:Q <60% are used, different rates of muscles imbalance might be obtained.

As a result, to show better performance and prevent possible lower limb injury, varsity football players who are actively training and competing might consider taking strength asymmetry into account as our study showed DOM Quadriceps is stronger than ND Quadriceps at $60°·s^{−1}$ and there is side-to-side strength asymmetry in both Quadriceps and Hamstring at $300°·s^{−1}$.

Postgraduate thesis

This manuscript was the part of postgraduate thesis of Enver Tatlıcıoğlu titled "Investigatıon of the Relationship between Amerıcan Football Players' and their Positions with Dynamic Strength, Athletic Performance and Isokokinetic Strength Tests" at Girne American University, Institute of Social Science, Master of Physical Education Teaching.

Conflict of interest

None.

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