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SportMont

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Association Between Hamstrings' Eccentric Strength and Sprint Performance in Football Players

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Abstract

Sprint is essential for successful sport performance. Acceleration is necessary for every position in football. The ability to successfully accelerate is also an important determinant for more carried gaming activities. The eccentric strength of the hamstrings is an important task in sprint. The aim of our study was to test the correlation between the 30 m sprint and the eccentric strength of the hamstring by NordBord. The sample consisted of 48 professional football players (23.15±4.78 yr.; 180.5±5.42 cm; 76.5±7.94 kg) of the highest Slovak football league. The correlation between 30 m performance and average eccentric hamstring strength has been -0.0826. The correlation suggests that the sprint speed and eccentric strength of the hamstrings have not been associated 0 (t=-0.5619; df=46; p=0.5769). Correlation between 30 m performance and AVG/kg was -0.1317, indicating that the correlation between average weight and speed was not been significant. The eccentric strength has not been associated with a higher speed in the 30-m sprint test. However, more intervention studies are warranted.

Keywords: *speed, eccentric muscle strength, hamstring, football*

Introduction

Football is one of the most popular sports. Movement of the football player is composed of more components, including jogging, running, and sprinting. During a match, an elite football player runs approximately 10-11 km, of which 25-27% is walking, 37-45% is jogging, 6-8% is backward running, 6-11% is sprinting and the rest 20% is movement in solving individual game activities (Dolci et al., 2018). Successful performance in football depends on physiological, nutritional, technical, tactical, social and psychological parameters (Gonçalves et al., 2014; Randers et al., 2018)modified training impulse, body load and movement behaviour between defenders, midfielders and forwards, during an 11-a-side simulated football game. Twenty elite youth male footballers from the same squad participated in this study (age: 18.1 ± 0.7 years old, body mass: 70.5 ± 4.3 kg, height: 1.8 ± 0.3 m and playing experience: 9.4 ± 1.3 years. Sprint is a significant part of overall performance. The ability of a football player to sprint significantly interferes with the successful completion of gaming activities. Every position of a football player requires acceleration. The ability to accelerate successfully is also an important determinant of several tactically performed gaming activities. The eccentric strength of the hamstrings plays an important role in sprinting (Stanton & Purdam, 1989). Sprint biomechanics requires significant activation of eccentric muscle strength during the swing phase. Sprinting is essential for successful sports performance. Sprint in football consists of alternating concentric and eccentric muscle activity, especially of the lower limbs. However, the involvement of a large number in muscles of the whole body is required for sprinting in football (Howard et al., 2018). Biomechanical variables that affect sprint include reaction time, technique, force production, neuromuscular factors, and muscle architecture. The technique represents the sprinter's ability to accelerate by increasing stride length and stride speed. High neuromuscular muscle activity during the acceleration phase means that the sprinter can reach its maximum nerve activity during the acceleration phase, which subsequently decreases (Higashihara et al., 2015). Sprint requires

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a comprehensive sequence of muscle activation throughout the body. Several types of exercises are used in speed training for athletes. Eccentric exercise is known to be important in injury prevention (van der Horst et al., 2015). Theoretically, the resulting increased hamstring power and neuromuscular activity could improve sprint performance and help a football player accelerate his performance. Therefore, the objective of our study is to test the correlation between the 30-m sprint and the eccentric muscle strength of the hamstrings.

Methods

The sample consisted of 48 football players of the highest Slovak football league (23.15±4.78 yr.; 180.5±5.42 cm; 76.5±7.94 kg). Research was carried out in February 2020 after finishing the first part of the preparation season. The criteria for the inclusion of football players have been the following: age over 17, participation in the highest national league, regular participation in training. Research has not conducted players younger than 17 years of age, with injury of the muscular system or acute infection.

Subsequently, all athletes have undergone a 30 m linear sprint test measured by Witty Microgate photocells. Microgate Polifemo photocells work as a coaxial optical system. Additionally, the Polifemo line employs an intelligent link to the timer using the standard 2-wire banana connection. NordBord has implemented a maximum eccentric hamstring test (Figure 1). The NordBord Hamstring Testing System is a device based on measurement of eccentric and isometric hamstring strength. NordBord was invented by Vald Performance company established in Australian Newstead. The majority of NordBord consists of an area for athletes to kneel on. Once kneeling, athletes insert their ankles into padded ankle hooks and then perform a movement to measure eccentric and isometric hamstring strength. Ankle hooks include a sensor which measures the force of muscle activity (in Newtons). NordBord sensors must be in a perpendicular position towards the ground for successful test completion. The NordBord device allows testing of eccentric and isometric muscle activity. NordBord also allows testing in other positions, such as Razor Curl. The main advantage of NordBord is that testing is performed quickly.

Testing process

Before testing, all athletes have undergone a uniform form of warm-up, according to the RAMP protocol (Raise - Activation - Mobilization - Potentiation) with a duration of 15 minutes. Collective warm-up has been followed by individual 5-minute warm-up and the start of the test. The 30 m distance has been labeled by photocells (as well as 5 m, and 10 m, 15 m) and set at the average height of the hip joint. The starting line has been located 0.5 meters in front of the position of the first photocell, where the players have started on their own initiative. The test has been performed on artificial grass and each athlete has had 2 attempts to give their maximum performance. Immediately after passing the sprint test, the NordBord device measured the eccentric force of the hamstrings.

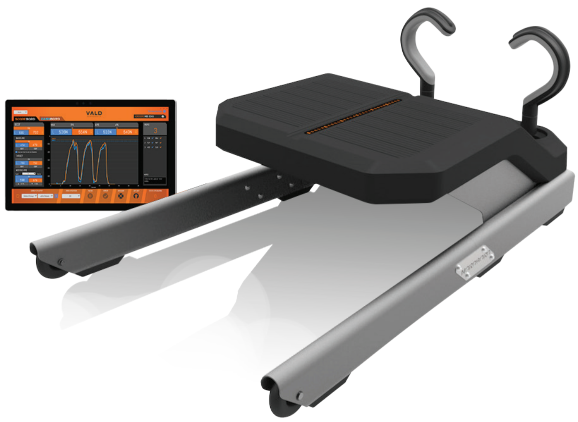

FIGURE 1. NordBord Hamstring Testing system

For research purposes, the maximum strength (N) (average of the lower limbs) that a player has been able to generate according to the sensors has been recorded. To determine the relative strength of the hamstrings, the obtained data were divided by the weight and athlethes' BMIs.

Before performing the test, itself, the athletes were in-

FIGURE 2. NordBord Testing

formed about its optimal design, pointed out its specifics, and showed the demonstration. After taking the correct position in the scoreboard section, the information about the position of the knees has been filled in, the sensors have been switched on, and the testing using the appropriate device with iOS software has started. The tested athletes have had a preview of the current test progress visible on the iPad screen throughout the testing. Athletes were required to maintain their knee, lumbar, and shoulder joints level for successful movement performance throughout implementation of the Nordic Hamstring Eccentric Test. In case of deviation from the optimal technique, increased attention has been paid to the athlete during the testing, resp. the test has had to be repeated. The players performed two repetitions of the required technical design.

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants involved in the study.

Statistical analysis

Pearson's correlation has been used for statistical processing. The correlation relationship between the variables has been clarified using a correlation matrix and graphically. For selected dependencies of variables, a graphical representation has been created using separate diagrams. Using the significance test of the correlation coefficient, it was tested whether the correlation between the 2 variables differs significantly from 0 or not. The distribution of the measured data, the regression curve, and the confidence interval of the regression curve are visible in the diagrams. In addition, for the individual axes, there is a box diagram according to the frequency of the occurrence of data on the axis. A significance level has been used, which is equal to α=0.05. A correlation analysis has been used via RStudio statistical software.

Results

The eccentric strength of the hamstrings has not been correlated with the higher sprint speed on the right side (r=-0.04; p>0.05) and on the left side (r=-0.13; p>0.05). No high level of correlation has been discovered, not even between BMI and the eccentric strength (r=0.4; p=0.118). A higher correlation rate has been discovered between eccentric strength and weight (r=0.48; p=0.019). The weight of the football players on the right side has not been associated with a sprint speed of 30 m (r=0.61; p<0.001) and on the left side (r=0.58; p<0.001). Another factor that has not been linked to hamstrings' eccentric strength of the hamstrings was age

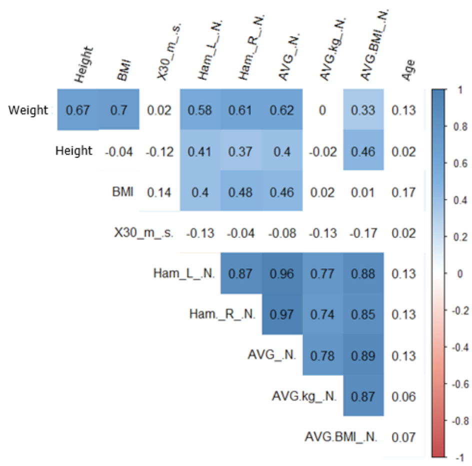

FIGURE 3. Correlation matrix

(r=0.13; p>0.05).

Part of the diagram is the value of the correlation coefficient, its significance, and a graphical representation of the variables in pairs, by pair comparison.

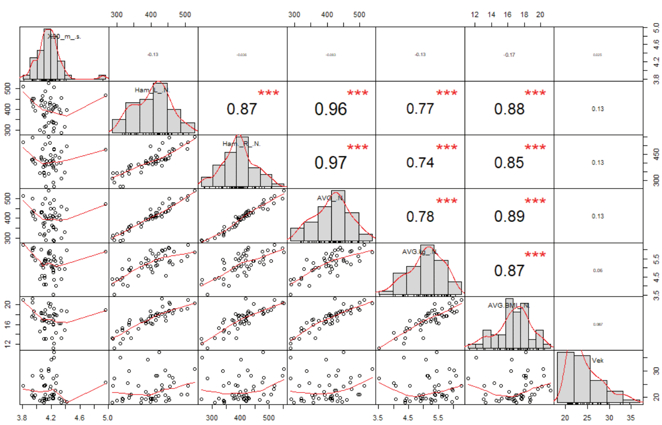

FIGURE 4. Hamstrings' eccentric strength with more factors

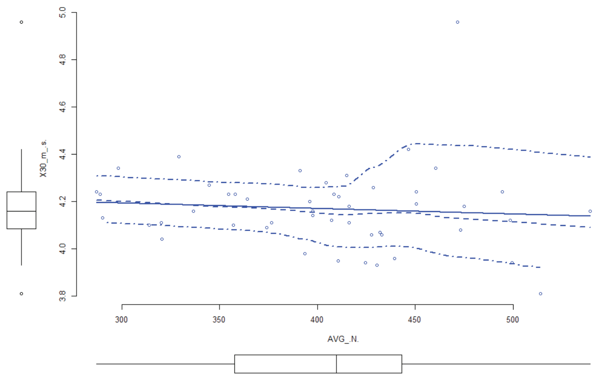

FIGURE 5. Comparison of 30m (s) and AVG (N)

Pearson's correlation between 30 m performance and AVG is -0.0826. The significance test of the correlation coefficient indicates that the sprint speed and the magnitude of the eccentric force of the hamstrings have not been associated with 0 (t=-0.5619; df=46; p=0.5769).

Pearson's correlation between 30 m performance and

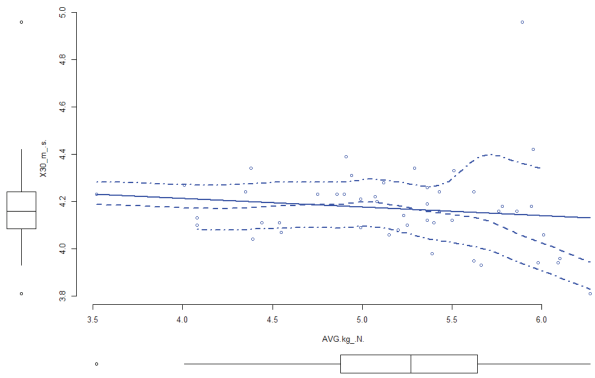

FIGURE 6. Comparison of 30 m (s) and AVG/kg (N)

AVG/kg is -0.1317, indicating that the correlation between average weight and speed is not significant. The test of significance of the correlation coefficient is equal (t=-0.90125; df=46; p=0.3722).

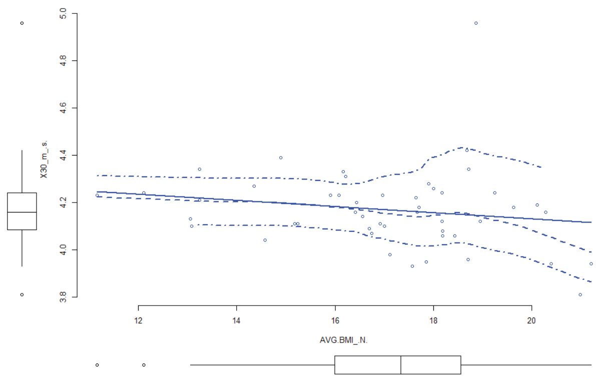

FIGURE 7. Comparison of 30 m (s) and AVG/BMI (N)

Pearson's correlation between 30 m performance and AVG/BMI is -0.1748, which means that the correlation value is only low. The significance of the correlation coefficient is equal to 0 (t=-1.2042; df=46; p=0.2347).

Pearson's correlation between age and AVG is 0.0248, which means that the 2 variables compared are independent. The significance of the correlation coefficient is equal to 0 (t=0.16802; df=46; p=0.8673). The combination of Pearson correlation coefficients and correlation coefficients' tests of significance can be given in one summary table (Table 1). Table 1 provides, among other information, the correlation coefficients, and the result of the correlation test (95% confidence interval and p values) for all pairwise comparisons of variables. Correlations of which p value (in the column named "p") is lower than a significance level 0.05, significantly differing from 0. In the last column, the level of significance has been marked with the number of stars.

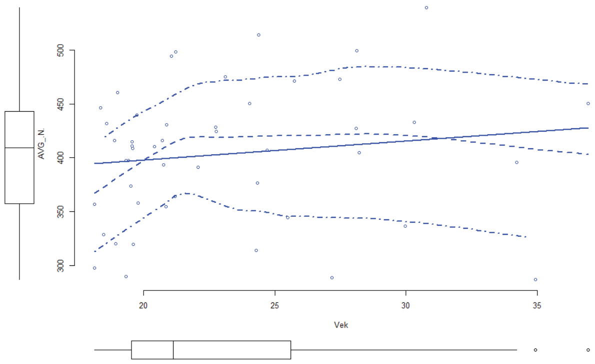

FIGURE 8. Comparison of Age and AVG (N)

Table 1. Comparison of Age and AVG (N)

Parameter1	Parameter2	r	95% CI	t(46)	p	Significance
Weight	Height	0.67	[0.48, 0.80]	6.13	<.001	***
Weight	BMI	0.70	[0.52, 0.82]	6.66	<.001	***
Weight	30m (s)	0.02	[-0.26, 0.30]	0.15	>.999	
Weight	Ham L (N)	0.58	[0.35, 0.74]	4.81	<.001	***
Weight	Ham R (N)	0.61	[0.40, 0.77]	5.29	<.001	***
Weight	AVG (N)	0.62	[0.40, 0.77]	5.32	<.001	***
Weight	AVG/kg (N)	-0.0045	[-0.29, 0.28]	-0.03	>.999	
Weight	AVG/BMI (N)	0.33	[0.05, 0.56]	2.40	0.474	
Weight	Age	0.13	[-0.16, 0.40]	0.87	>.999	
Height	BMI	-0.04	[-0.32, 0.25]	-0.27	>.999	
Height	30m (s)	-0.12	[-0.39, 0.17]	-0.83	>.999	
Height	Ham L (N)	0.41	[0.14, 0.62]	3.01	0.115	
Height	Ham R (N)	0.37	[0.10, 0.59]	2.71	0.227	
Height	AVG (N)	0.40	[0.13, 0.61]	2.96	0.121	
Height	AVG/kg (N)	-0.02	[-0.30, 0.27]	-0.11	>.999	
Height	AVG/BMI (N)	0.46	[0.21, 0.66]	3.55	0.026	*
Height	Age	0.02	[-0.27, 0.30]	0.13	>.999	
BMI	30m (s)	0.14	[-0.15, 0.41]	0.99	>.999	
BMI	Ham L (N)	0.40	[0.13, 0.62]	2.98	0.118	
BMI	Ham R (N)	0.48	[0.22, 0.67]	3.66	0.019	*
BMI	AVG (N)	0.46	[0.20, 0.65]	3.47	0.032	*
BMI	AVG/kg (N)	0.02	[-0.26, 0.30]	0.14	>.999	
BMI	AVG/BMI (N)	0.00623	[-0.28, 0.29]	0.04	>.999	
BMI	Age	0.17	[-0.12, 0.43]	1.18	>.999	
30m (s)	Ham L (N)	-0.13	[-0.40, 0.16]	-0.87	>.999	
30m (s)	Ham R (N)	-0.04	[-0.32, 0.25]	-0.25	>.999	
30m (s)	AVG (N)	-0.08	[-0.36, 0.21]	-0.56	>.999	
30m (s)	AVG/kg (N)	-0.13	[-0.40, 0.16]	-0.90	>.999	
30m (s)	AVG/BMI (N)	-0.17	[-0.44, 0.12]	-1.20	>.999	
30m (s)	Age	0.02	[-0.26, 0.31]	0.17	>.999	
Ham L (N)	Ham R (N)	0.87	[0.78, 0.93]	12.13	<.001	***
Ham L (N)	AVG (N)	0.96	[0.94, 0.98]	24.79	<.001	***
Ham L (N)	AVG/kg (N)	0.77	[0.62, 0.86]	8.16	<.001	***
Ham L (N)	AVG/BMI (N)	0.88	[0.79, 0.93]	12.48	<.001	***

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Table 1. Comparison of Age and AVG (N)

Parameter1	Parameter2	r	95% CI	t(46)	p	Significance
Ham L (N)	Age	0.13	[-0.16, 0.40]	0.92	>.999	
Ham R (N)	AVG (N)	0.97	[0.95, 0.98]	27.40	<.001	***
Ham R (N)	AVG/kg (N)	0.74	[0.58, 0.85]	7.54	<.001	***
Ham R (N)	AVG/BMI (N)	0.85	[0.74, 0.91]	10.77	<.001	***
Ham R (N)	Age	0.13	[-0.16, 0.40]	0.86	>.999	
AVG (N)	AVG/kg (N)	0.78	[0.64, 0.87]	8.47	<.001	***
AVG (N)	AVG/BMI (N)	0.89	[0.81, 0.94]	13.26	<.001	***
AVG (N)	Age	0.13	[-0.16, 0.40]	0.92	>.999	
AVG/kg (N)	AVG/BMI (N)	0.87	[0.78, 0.93]	12.06	<.001	***
AVG/kg (N)	Age	0.06	[-0.23, 0.34]	0.41	>.999	
AVG/BMI (N)	Age	0.07	[-0.22, 0.34]	0.45	>.999	

Note AVG = average; Ham L = hamstrings' strength (left leg); Ham R = hamstrings' strength (right leg); r

Discussion

In the study, the eccentric strength has not correlated with the sprint speed according to the 30-m sprint. A potential explanation may be that an isolation of one factor that would relate to the speed is difficult (Nikolaidis et al., 2016). In our study, a low correlation between the eccentric strength and speed has been observed according to the 30 m sprint. The speed of a football player is made up of several factors that can contribute to a higher speed of a football player. The critical factors that have been correlated together were weight and eccentric strength. This can be explained by the design of the device due to the effect of weight on the optimal performance of the Nordic hamstring exercise with the NordBord device. The inability to take the athlete's weight into account may result in distortion results in terms of the eccentric strength. An athlete with a lower weight is more likely to have a lower eccentric final hamstring strength than an athlete with a higher weight. However, it is not the rule that the athlete with the higher weight will have the strongest eccentric hamstring strength. Another important limitation was correlation testing and not intervention by footballers. The correlation indicates the possible association of two or more variables.

The benefit of performance improvement is better to be verified with intervention studies aimed at improving the speed of footballers. When measuring the eccentric strength on the NordBord, the athlete performs a Nordic hamstring exercise. The effectiveness of the Nordic hamstring to sprint speed has been tested by Ishoi et al. (I2018). The exercise protocol lasted 10 weeks. The group consisted of 35 footballers, who were divided into an intervention group (n-18) and a control group (n-17). The intervention group has improved its eccentric hamstring strength (62.3 N, p=0.006, d=0.92). The effectiveness of Nordic hamstring exercise has also been tested in a study by Krommes et al. (Krommes et al., 2017). The group consisted of 19 football players with the Nordic hamstring exercise, which was included 27 times in the training unit. An improvement in short-distance sprint performance has been recorded in the intervention group compared to the control group. A smaller decrease in sprint speed has been recorded after 30 m. Counter movement jump (CMJ) has improved in both groups. According to Krommes et al., the use of eccentric exercises does not lead to worsening of football players and, on the other hand, it can be beneficial in improving explosive abilities.

Siddle et al. (Siddle et al., 2019)10m sprint speed, and change-of-direction (COD have tested the acute effect of Nordic hamstring exercise on speed and strength. The group consisted of 14 footballers, who were randomly divided into an intervention group (n-7) and a control group (n-7). An improvement in eccentric strength has been observed in the intervention group (31.81 Nm-1 vs 6.44 Nm-1, P=0.001) speed according to the change of direction test (-0.12s vs. 0.20 s; p=0.003) and the sprint (-0.06 s). vs. 0.05 s; p=0.024). The aim of the study by Mendiguchia et al. (2020) was to compare the effect of eccentric exercise with sprint training on sprint performance and its mechanical foundation, as well as on the architecture of the long head of the biceps femoris. The group consisted of 32 footballers, who completed a 6-week programme before the season - the „soccer group" (n =10), the „nordic group" (n=12), and the „sprint group" (n=10). The most significant changes occurred in the 'Sprint group'; small negative changes have been recorded in the 'Soccer group' and 'Nordic group'. In the group that underwent sprinting exercises, the training has led to an extension of the muscle fascicles of the hamstrings. In the group practicing the Nordic hamstring, an increase according to the pennation angle. Sprint training was more effective than eccentric exercise in improving speed. Freeman et al. (2019) have also tested the effectiveness of the Nordic hamstring to sprint speed and the size of the eccentric strength has also been tested by Freeman et al. (2019). The group consisted of 28 athletes, who have been randomly divided into a group that practiced sprint training and a group that underwent eccentric Nordic hamstring exercises. Improvements have been observed in eccentric muscle strength (ES=0.39, P<0.05) and sprint speed (ES=0.29, P<0.05) have been observed in both groups. The meta-analysis by Cuthbert et al. (2020) has tested the effect of the Nordic hamstring on the size of the eccentric muscle strength and the hamstring architecture. Thirteen studies have been included in the analysis. An improvement in the hamstring eccentric strength has been reported in athletes. Similar results have been reported for changes in fascicle length (g 2.58) and a large-to-very large positive reduction in pennation angle (g≥1.31). The differences have been estimated to be of magnitude of 0.374

(p=0.009) for strength and 0.793 (p<0.001) for architecture. A meta-analysis by Seitz et al. (2014)whether increases in lower-body strength transfer positively to sprint performance remain unclear.\nOBJECTIVES: This meta-analysis determined whether increases in lower-body strength (measured with the free-weight back squat exercise has evaluated the association between increased lower limb muscle strength and speed. The analysis has included 15 studies (n-510). An increase in lower limb strength has been associated with an increase in athlete speed (r=-0.77; p=0.0001). The effectiveness of eccentric muscle exercise is known from the point of view of preventing hamstring injury. The aim of the study by Van der Horst et al. (2015) was to test the effectiveness of Nordic hamstring exercise on the incidence and severity of hamstring injuries. The intervention group consisted of 292 football players and the control group consisted of 287 football players. The Nordic hamstring exercise lasted 13 weeks. There has been a significant reduction in the incidence of hamstring injuries in the regular exercise group, but Nordic hamstring exercise has not affected the severity of the injury. The effectiveness of Nordic hamstrings on prevalence and incidence has also been tested by Petersen et al. (2011) who have tested 461 footballers compared to 481 footballers who did not train Nordic hamstrings. The exercise lasted for 10 weeks. There were 52 hamstring injuries in the control group and 15 injuries in the intervention group. According to Petersen et al., the inclusion of eccentric exercises leads to a significant reduction in hamstring injuries. The purpose of the study by Líška et al. (2019)which is associated with significant economic costs and high demand for sport rehabilitation. Exercise for eccentric muscle strength of the posterior thigh muscles plays an important role in prevention. Objective: The main goal of our study is to compare eccentric muscle strength of the posterior thigh muscles in elite hockey players and elite football players, and also to identify the risk of injury in both groups. Methods: NordBord Hamstring Testing System is an equipment designed to measure eccentric and isometric strength of hamstrings. Nordbord's main focus is on the eccentric muscle strength in exercise which is called Nordic Hamstring. Sample: Our sample included professional hockey players (n = 30 was to test the size of the eccentric muscle strength in professional hockey players and football players. The tested group consisted of 30 professional hockey players and 30 football players. The average values of eccentric muscle strength in hockey players were 419.8 N on the left hamstring and 420.9 N on the right hamstring. For football players, the average values of eccentric muscle strength have reached the following values: left hamstring 419.6 N, right hamstring 428.6 N. There were no statistically significant differences between football players and hockey players in terms of the size of the eccentric strength.

Conclusion

The hamstrings' eccentric strength has not been associated with a higher speed in the 30 m sprint test. However, more intervention studies are warranted.

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There are no acknowledgments.

Conflict of Interest
The author declares that there is no conflict of interest.

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