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Unravelling the Relationship between External Load and the Incidence of Hamstring Injuries in Professional Soccer Players

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Abstract

Objectives. The study aimed to analyze external load indicators with the incidence of non-contact hamstring injuries.

Material and methods. A non-experimental correlative, retrospective cohort study was carried out. The data were collected from 31 professional male soccer players over the course of one season. The following load indicators were examined: duration (D), total distance travelled (TDT), distance travelled at high intensity (DTHI) > 20 km/h, number of efforts between 20-25 km/h (NE 20-25 km/h), distance travelled at more than 25 km/h (DR+25 km/h), number of sprints greater than 25 km/h (NE > 25 km/h), number of accelerations greater than 1 m/s^2 (Acc), and number of minor decelerations at -1 m/s^2 (Dcc). Only non-contact hamstring injuries were included in the analysis. For the multivariate analysis, we applied a logistic regression model, where a value of $p < 0.05$ was established both for the statistical significance of the model (X^2) and for each of the regressor variables (X^2), the confidence interval level was 95%.

Results. Two injuries were recorded and diagnosed: injury grade 2 and muscle fatigue. The load indicators analyzed did not show a significant correlation with hamstring injury. Therefore, no association was found between external load and hamstring injury in professional soccer players.

Conclusions. The logistic regression model ($p > 0.05$) did not present statistical significance. Consequently, none of the external load variables monitored explain the rate of non-contact hamstring injuries in this population.

Keywords: external load indicators, hamstring injury, global positioning system (GPS).

Introduction

For García Romero (2022), in high-level sport, the physical and psychological requirements are essential; to evaluate them, different types of monitoring of athletes are carried out to assess their capacity to assimilate loads and their state of recovery to be able to face training. or a match. In Soccer, the need to evaluate the player correctly means that different markers are analyzed to identify the player's status to compete at the highest level of his/her ability. According to Barnes et al. (2014) Soccer has become a much faster, more intense and more competitive game, with physical and technical demands that have increased significantly. Newton et al. (2019) consider that the player must prepare for the high physical demands that arise in training and matches. Wallace et al. (2014) indicate that the external load is the work done by the athlete in variables such as distance traveled, number of sprints, accelerations, decelerations. According to Gabbett (2016), this load refers to the athlete's locomotor movements that can be monitored and measured with global positioning systems (GPS). This being an instrument of validity and reliability (Casamichana et al., 2013), approved by the Federation International Football Association (FIFA, 2015). For Halson (2014), training load monitoring has become a modern scientific approach that allows us to better understand athletes' training responses and preparation for competition. Rago et al. (2019) suggest that this technological advance allows optimization of the monitoring, control and quantification processes of the load in training and competition. Jaspers et al. (2016) indicate that tracking and monitoring the load allows optimizing training processes and planning strategies for injury prevention. Gabbett & Domrow (2007) state that a correct balance between training and competition load with optimal recovery is essential to achieve maximum performance and of great importance in injury prevention. Baztán (2018) states that one of the most frequent injuries in soccer is the hamstring, the most common injury mechanism being linear sprinting at maximum speed, presenting the highest injury incidence at the end of matches, which raises suspicion of the fatigue as a risk factor for injury in soccer. On their behalf, Garrett et al. (1984) state that this muscle group has the capacity to produce large forces, having an impact on actions such as: accelerations, decelerations, high-speed actions and changes of direction. Ekstrand et al. (2011) found that 12% of the injuries recorded during a season occurred in the hamstrings, generating approximately 80 days of absence, in addition to the economic cost that this implies. According to Ekstrand et al. (2022) in recent seasons hamstring injuries have increased, the authors described the injury incidence in professional soccer players during 21 seasons (2001/02 to 2021/22). There were 2,636 hamstring injuries, which represented 19% of all reported injuries. The proportion of injuries increased from 12% during the first season to 24% in the most recent season. In this same period, the percentage of days of absence due to said injury increased from 10% to 20%. Raya & De la Torre (2018) highlight the importance of quantifying the load to improve performance and reduce injuries. Knowing the individual demands in training allows us to identify if the player manages to reproduce the demands in competition, important information for the coaching staff in the application of specific stimuli and work that can cover the demands of each athlete. Jaspers et al. (2018) demonstrated that load indicators, mainly external ones, are associated with a greater or lesser risk of injury, recommending the monitoring of different load indicators for the prevention of injuries in professional soccer.

Objective. Determine the association of external load with the incidence of hamstring injuries in professional soccer players.

Hypothesis. Null hypothesis (Ho): There is no association between external load and the incidence of hamstring injuries in professional soccer players. Alternate hypothesis (Ha): There is an association between external load and the incidence of hamstring injuries in professional soccer players.

Material and Methods

Participants

Thirty-one professional soccer players (age 25.2 ± 4.8 years, weight 77.0 ± 7.8 kg, height 181.1 ± 8.3 cm, BMI 23.4 ± 1.6 kg/cm^2) participated in the present study. The ethical aspects promulgated in the Declaration of Helsinki for research in human beings were taken into account, as well as the provisions of Resolution 8430 of 1993 of the Ministry of Health of Colombia, and in accordance with it the study is classified as having minimal risk for the subjects. All agreed to participate in the study, which was protocolized by signing the informed consent. The endorsement of the ethics committee of the University Institute of Physical Education and Sports at the University of Antioquia was obtained through document No. 069 of December 14, 2020.

Data Collection

It was carried out following the guidelines for GPS data collection and processing. All training sessions and matches were individually quantified using 10 Hz GPS technology (Catapult – OptimEye S5). For Scott et al. (2016) the GPS is an instrument independently validated in more than 100 peer-reviewed scientific journals worldwide. This sampling frequency has demonstrated validity and reliability for high movement demands at high intensity in team sports. The selected external load indicators were: duration (minutes), total distance traveled (m), distance traveled at high intensity (>20 km/h, equivalent to 5.56 m/s) (m), number of efforts 20-25 km/ h, distance traveled (+25 km/h, equivalent to 6.94 m/s) (m), 30 m sprints between 6-7 m/s^2, number of accelerations (>1 m/s^2) and number of decelerations (<– 1 m/s^2).

The injuries were diagnosed and recorded by members of the professional soccer club's medical staff. Following the recommendations of Fuller et al. (2006) data collection procedures were carried out in accordance with the consensus statement for soccer injury studies endorsed by the FIFA Medical Assessment and Research Centre, coding each diagnosis by location, type and mechanism of injury (traumatic or overuse). The study recorded non-contact hamstring injuries during the 2021-1 season. It is worth noting that the data were collected during the global pandemic derived from COVID-19, which probably could have generated alterations in the conditional expression of the soccer players (both in training and in competition).

Design and Procedures

A non-experimental correlative retrospective cohort study was carried out on thirty-one professional soccer players during the 2021-1 season. 145 training sessions and 26 games were monitored.

The information on the external load was collected by the club's performance analyst using GPS; for the field training sessions, he placed the devices on each player in their respective vests before starting the activities, which were identified with the competition jersey number, subsequently verifying that each of these were being registered correctly. Data were monitored and recorded for each period during the training session. Recovery times were not included. At the end of the last period, the devices were turned off and collected for later downloading data to the software (Catapult OptimEye, S5). For the matches, the same procedure used in training was applied to the selected players; they turned on when they went out to warm up, at the end of the match they turned off and they were collected for the subsequent download of data.

Hamstring overuse injuries during the 2021-1 season were diagnosed and recorded by the club doctor after analyzing the MRI results, confirming the diagnosis of hamstring muscle tear and evaluating which muscle was affected and the extension that presented such tear. Each diagnosis was characterized by its location, type, mechanism of injury, time of injury, training or match, and days of disability. The previous information was sent by the club doctor to the performance analyst and the latter to the main researcher to update data on the event that occurred.

Statistical Analysis

The information collected was recorded and stored in an Excel spreadsheet. Once the quality of the information had been refined and reviewed, it was exported for its respective analysis in the SPSS V.27 and RStudio V.4.0 programs.

For the exploratory analysis, descriptive statistics were used (mean, median, standard deviation, coefficient of variation and interquartile range) depending on the type of distribution of the variables, which was established from the Shapiro-Wilk test. For the correlative and association analysis between variables, the chi-square, Pearson's r, Spearman's r and point biserial correlation coefficient tests were used, which depended on the type of variables to be related. For the multivariate analysis, a logistic regression model was used, where a value of $P<0.05$ was established both for the statistical significance of the model (X^2) and for each of the regressor variables (X^2), the interval confidence level was 95%.

Results

Table 1 indicates the general profile of the external load indicators per training session of the team, minimum, maximum and percentiles.

Table 2 reveals the descriptive statistics referring to the external load regressor variables in competition during the 2021-1 season.

Table 3 describes the statistical results for the different external load indicators by position in competition, where the longest duration (playing time) occurred in the goalkeeper position; the greatest total distance traveled was on the midfielders; In the lateral position, the maximums are reflected in what corresponds to the total distance traveled at high intensity, efforts between 20-25 km/h, the distance traveled at more than 25 km/h, number of sprints and number of accelerations. Finally, the greatest number of decelerations in the central position.

The external load indicators analyzed did not present any significant correlation with hamstring injury, therefore, no association of load with non-contact hamstring injury was found. However, the load presents a positive correlation between the different indicators, revealing that the non-contact hamstring injuries that occurred during the season were possibly due to other factors (table 4).

During the season, two players presented with a non-contact hamstring injury, with a diagnosis of grade two injury and muscle fatigue, generating 47 and 10 days of disability, in the lateral and winger positions respectively. The stepwise model discards the regressor variables; none of them are able to predict the probability of occurrence with the hamstring injury (Table 5).

The logistic regression model ($p<0.05$) did not present statistical significance (Table 6), consequently, none of the monitored external load regressor variables explains the rate of hamstring injuries in this population.

Table 2. Descriptive statistics referring to the competing external load variables (regressors)

Variables	Statistical	Results
D (playing time) (min)	Mean	64
	S.D.	22
DTR (m)	Mean	5740
	S.D.	1963
DTRAI 20-25 km/h (m)	Mean	267
	S.D.	135
Esf. 20-25 km/h (No.)	Mean	20
	S.D.	11
DTR +25 km/h (m)	Median	117
	Interc range	107
Sprints >25 km/h (No.)	Median	6
	Interc range	6
Acc. >1 m/s^2 (No.)	Median	14
	S.D.	5
Des. <-1 m/sec^2 (No.)	Median	16
	Interquartile range	10

(D) Duration (min), (DTR) Total distance traveled (m), (DTRAI) Total distance traveled at high intensity 20-25 km/h (m), (E) Efforts between 20-25 km/h, (DTR) Total distance traveled at more than 25 km/h (m), (Sprints) 30 m between 6-7 m/s^2, (Acc.) Number of accelerations (>1m/s^2), (Dcc.) Number of decelerations (<−1 m/s^2)

Table 1. General load profile per training session

		D (min)	DTR (m)	DTRAI (m)	E 20-25 km/h (No.)	DTR +25km/h (m)	Sprints (No.)	Acc. (No.)	Dcc. (No.)
Minimum		31.3	1200.6	23	0.3	0.8	0.2	6.4	8.8
Maximum		78.0	5810.4	214.1	15.8	115.5	6.0	25.5	54.2
Percentiles	25	52.7	2899.0	60.4	5.2	13.3	0.8	11.3	13.7
	50	56.0	3873.6	89.6	7.0	22.5	1.6	14.3	19.6
	75	65.0	4188.1	121.9	10.8	43.1	2.8	17.3	27.9

(D) Duration (minutes), (DTR) Total distance traveled (m), (DTRAI) Total distance traveled at high intensity 20-25 km/h (m), (E) Efforts between 20-25 km/h, (DTR) Total distance traveled at more than 25 km/h (m), (Sprints) 30 m between 6-7 m/s^2, (Acc.) Number of accelerations (>1m/s^2), (Dcc.) Number of decelerations (<−1m/s^2)

Table 3. External load indicators in competition by position

Position	N	Statistical	D (min)	DTR (m)	DTRAI 20-25 km/h (m)	Esf. 20 and 25 km/h (No.)	DR (+25 km) (m)	Sprints (No.)	Acc. (No.)	Dcc. (No.)
Goalkeeper	2	Max.	97.8	4201	58	7	15	1	12	13
		Min.	71.3	3520	12	1	2	0	8	13
		Mean	84.6	3860	35	4	8	1	10	13
		S.D.	18.7	481	33	4	9	1	3	1
Central	5	Max.	89.1	8104	450	38	298	16	18	47
		Min.	39.9	3329	118	9	61	3	11	12
		Mean	73.9	6448	291	23	155	8	14	25
		S.D.	20.0	1918	148	12	92	5	3	13
Winger	5	Max.	87.8	8257	554	44	381	19	21	32
		Min.	17.0	1818	123	10	69	4	0	0
		Mean	54.2	5315	315	25	195	10	12	17
		S.D.	26.3	2394	176	14	140	7	8	12
Midfielders	7	Max.	94.8	8925	478	38	211	12	23	29
		Min.	34.0	3266	94	8	0	0	7	11
		Mean	69.4	6830	297	21	96	5	16	18
		S.D.	21.3	1928	122	10	71	4	6	6
Wing Forward	5	Max.	79.3	7755	345	26	242	12	16	22
		Min.	30.4	2991	116	7	39	2	9	6
		Mean	50.5	4983	262	19	142	7	12	14
		S.D.	20.4	1925	94	8	76	4	3	7
Forward	3	Max.	71.1	6135	253	19	132	7	18	17
		Min.	36.7	3907	207	15	79	4	9	15
		Mean	57.2	5241	235	17	97	5	14	16
		S.D.	18.1	1178	25	2	30	2	5	1

(N) Quantity, (Est.) Statistics, (D) Duration (min), (DTR) Total distance traveled (m), (DTRAI) Total distance traveled at high intensity 20-25 km/h (m), (E) Efforts between 20-25 km/h (N°), (DTR) Total distance traveled at more than 25 km/h (m), (Sprints) 30 m between 6-7 m/s^2, (Acc.) Number of accelerations (>1 m/s^2), (Dcc.) Number of decelerations (<−1 m/s^2)

Discussion

The objective of the study was to determine the association of different external load indicators with the incidence of non-contact hamstring injuries in professional soccer players. Verstappen et al. (2021) in their systematic review took into account the evaluation of external load parameters: duration, total distance traveled, high-speed running and acceleration, they did not find sufficient evidence or significant correlation of association between training load and injury risk in elite youth soccer players. and that non-contact muscle injuries may have possibly been due to other factors. Similar results were obtained in the present study in which similar external load indicators were analyzed, which did not present an association with non-contact hamstring injury.

Jaspers et al. (2018) demonstrated that load indicators, mainly external ones, are associated with an increase or decrease in the risk of injuries. On the contrary, for this investigation the results demonstrated that the external load indicators do not present an association with the risk of non-contact hamstring injury. Likewise, Jaspers et al. (2018) analyzed data from 35 male professional soccer players during two seasons (2014-2015 and 2015-2016), recording 64 overuse injuries. For 21 consecutive seasons Ekstrand et al. (2022) collected data from 3909 players from 54 teams (in 20 European countries) from 2001/02 to 2021/22, concluding that the proportions in hamstring injuries in number of injuries and days of total absence doubled during the study period. Additionally, they found that over the past eight seasons, hamstring injury rates increased in both training and matches. The season analyzed in this study was carried out with a single team during the 6-month season (2021-1), recording 2 non-contact hamstring injuries.

The professional soccer club under research for the 2021-1 season presented a low non-contact hamstring injury rate, reaching the final stages of the championship. In a study

Table 4. Correlation of external load indicators with non-contact hamstring injury

External load indicators		D (min)	DTR (m)	DTRAI 20-25km/h (m)	Esf. 20 and 25 km/h	DR (+25km/h) (m)	Sprints	Acc.	Dcc.	Hamstring injury
D (min)	Coef. corr.	1.000	0.688 **	0.428 *	0.450 *	0.319	0.390 *	0.627 **	0.231	0.220
	Sig. (bil.)		0.000	0.016	0.013	0.092	0.049	0.000	0.210	0.234
DTR (m)	Coef. corr.	0.688 **	1.000	0.740 **	0.706 **	0.520 **	0.418 *	0.517 **	0.456 **	0.220
	Sig. (bil.)	0.000		0.000	0.000	0.004	0.033	0.003	0.010	0.234
DTRAI 20-25km/h (m)	Coef. corr.	0.428 *	0.740 **	1.000	0.963 **	0.753 **	0.680 **	0.283	0.475 **	0.294
	Sig. (bil.)	0.016	0.000		0.000	0.000	0.000	0.123	0.007	0.109
Esf. 20 and 25 km/h (No.)	Coef. corr.	0.450 *	0.706 **	0.963 **	1.000	0.838 **	0.809 **	0.369 *	0.455 *	0.262
	Sig. (bil.)	0.013	0.000	0.000		0.000	0.000	0.045	0.012	0.161
DR (+25km/h) (m)	Coef. corr.	0.319	0.520 **	0.753 **	0.838 **	1.000	0.983 **	0.139	0.206	0.293
	Sig. (bil.)	0.092	0.004	0.000	0.000		0.000	0.471	0.284	0.123
Sprints (No.)	Coef. corr.	0.390 *	0.418 *	0.680 **	0.809 **	0.983 **	1.000	0.173	0.285	0.289
	Sig. (bil.)	0.049	0.033	0.000	0.000	0.000		0.398	0.158	0.152
Acc. (No.)	Coef. corr.	0.627 **	0.517 **	0.283	0.369 *	0.139	0.173	1.000	0.249	0.242
	Sig. (bil.)	0.000	0.003	0.123	0.045	0.471	0.398		0.177	0.189
Dcc. (No.)	Coef. corr.	0.231	0.456 **	0.475 **	0.455 *	0.206	0.285	0.249	1.000	-0.007
	Sig. (bil.)	0.210	0.010	0.007	0.012	0.284	0.158	0.177		0.969
Hamstring injury	Coef. corr.	0.220	0.220	0.294	0.262	0.293	0.289	0.242	-0.007	1.000
	Sig. (bil.)	0.234	0.234	0.109	0.161	0.123	0.152	0.189	0.969	

**The correlation is significant at the 0.01 level (two-sided). *The correlation is significant at the 0.05 level (two-sided).
(D) Duration (min), (DTR) Total distance traveled (m), (DTRAI) Total distance traveled at high intensity 20-25 km/h (m), (E) Efforts between 20-25 km/h, (DTR) Total distance traveled at more than 25 km/h (m), (Sprints) 30 m between 6-7 m/s^2, (Acc.) Number of accelerations (>1 m/s^2), (Dcc.) Number of decelerations (<−1 m/s^2)

Table 5. Stepwise model of the regressor variables

Variables	Punctuation	gl	Next.
D (min)	0.010	1	0.919
DTR (m)	0.149	1	0.699
DTRAI (20-25 km/h) (m)	0.209	1	0.647
Esf. 20 and 25 km/h (No.)	0.062	1	0.804
Sprints (No.)	0.222	1	0.637
Acc. (No.)	0.085	1	0.771
Dcc. (No.)	0.577	1	0.447
Global statistics	4.725	7	0.694

(D) Duration (min), (DTR) Total distance traveled (m), (DTRAI) Total distance traveled at high intensity 20-25 km/h (m), (E) Efforts between 20-25 km/h, (Sprints) 30 m between 6-7 m/s^2, (Acc.) Number of accelerations (>1 m/s^2), (Dcc.) Number of decelerations (<−1 m/s^2)

Table 6. Omnibus tests of model coefficients

	Steps	Chi squared	gl	Q
Step 1	Step	3.5	1	0.061
	Block	3.5	1	0.061
	Model	3.5	1	0.061

conducted by Hägglund et al. (2013) found that teams with high injury rates did not perform well compared to those with low rates in major competitions in Europe. Although sprinting did not present an association with hamstring injury in the study, Lahti et al. (2020) propose sprinting as a potential risk factor for hamstring injuries, expressing an interest in analyzing the mechanical acceleration results of said action. For Morin & Samozino (2016) the results in the mechanical acceleration outputs in the sprint are important in training orientation. In this regard, Edouard et al. (2021) concluded that optimizing horizontal force production capacity during sprinting can improve sprint performance and reduce the risk of injury. In this sense Mendiguchia et al. (2021), relating sprint kinematics to hamstring injury and performance, examined whether a specific 6-week multimodal intervention (combination of lumbopelvic control exercises and running technique) could lead to changes in pelvic kinematics and the lower extremities in actions at maximum speed and improvement in sprint performance. These authors concluded that such a training program induced clear kinematic changes in the pelvis and lower extremities during maximum speed running, associating these changes collectively with a reduced risk of muscle strain and with a significant improvement in sprint performance.

Regarding accelerations and decelerations, Akenhead et al. (2013) indicate that the number of decelerations in a match is greater than the accelerations; similar results were presented in the present study in which these variables were analyzed. Important data when programming and directing the training process towards these actions, since in the face of continuous repetitions there could be fatigue at certain moments of the competition and training. For Lago (2014), this fatigue can occur due to maximum intensity efforts, acceleration and deceleration actions with and without the ball. For their part, Dalen et al. (2016) in addition to technical-tactical actions anticipating, running, jumping, intercepting, turning, changing direction, important efforts in the dynamics of current soccer and in the development of the competition that led to obtaining better results at the end of the matches. Given this trend, for Alonso (2018), an optimal organization and continuity of appropriate and specific stimuli in the soccer player's training process may allow them to cope with higher demands in the future.

For the analysis of the different external load indicators in competition during the season, contextual variables such as the state of the scoreboard, the level of the opponent and the location of the match were not taken into account. For Lucas (2020) these variables are important when analyzing a player individually or the team collectively during a season. The low incidence of non-contact hamstring injury reported in the study may indicate that training loads are being appropriately planned, monitored, and prescribed. Gabbett (2016) links high training loads and injuries, demonstrating that the problem is not in the training itself, but probably in inappropriately applied stimuli. Excessive and rapid increases in training loads are probably largely responsible for this type of injury.

Monitoring external load in training and matches is essential in the design and planning of adequate training to achieve optimal physical preparation for competition and reduce the risk of injury (Malone et al., 2017; Owen et al., 2015).

Conclusions

The logistic regression model (p>0.05) did not present statistical significance, consequently, none of the monitored external load regressor variables explains the rate of hamstring injuries in this population, therefore, based on the results found, it is not possible to reject the null hypothesis of the study.

During the 2021-1 season, there were 2 non-contact hamstring injuries, which can be established as a low number of injuries for professional soccer players of the Club under investigation. Therefore, it can be considered that the findings regarding the training and competition load developed by the athletes were adequate in terms of the low number of hamstring injuries that occurred, possibly this aspect has decreased the risk of injuries of those soccer players, during that specific period of time.

It is noteworthy that the results obtained in the present study correspond to professional soccer players from a specific club during the 2021-1 season, therefore, the findings cannot be generalized since they were presented in a specific population, season and competition under conditions individuals (during the pandemic generated by COVID-19).

Limitations

It is important to recognize and declare that the study was developed during critical episodes of the pandemic generated by COVID-19, which generated difficulties and modifications due to mobility, training and competition restrictions. Likewise, the study was carried out during the 2021-1 season, making it a short period of time for the analysis of the variables of interest. The results of this study are only inferable to the players of the professional team investigated.

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З'ясування взаємозв᾽язку між зовнішнім навантаженням і частотою травм підколінного сухожилля у професійних футболістів

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 7 с., 6 табл., 33 джерела.

Мета. Метою дослідження було проаналізувати показники зовнішнього навантаження з частотою виникнення неконтактних травм підколінного сухожилля.

Матеріал та методи. Було проведено неекспериментальне кореляційне, ретроспективне когортне дослідження. Дані були зібрані у 31 професійного футболіста чоловічої статі протягом одного сезону. Досліджено наступні показники навантаження: тривалість (D), загальна пройдена відстань (TDT), відстань, пройдена з високою інтенсивністю (DTHI) > 20 км/год, кількість зусиль між 20-25 км/год (NE 20-25 км/год), відстань, пройдена зі швидкістю понад 25 км/год (DR+25 км/год), кількість спринтерських забігів понад 25 км/год (NE > 25 км/год), кількість прискорень понад 1 м/с^2 (Acc) та кількість незначних сповільнень до -1 м/с^2 (Dcc). До аналізу були включені лише неконтактні ушкодження підколінного сухожилля. Для багатовимірного аналізу було застосовано логістичну регресійну модель, де було встановлено значення $p < 0,05$ як для статистичної значущості моделі (X^2), так і для кожної зі змінних регресорів (X^2), рівень довірчого інтервалу становив 95%.

Результати. Зафіксовано та діагностовано наявність двох травм: ушкодження другого ступеня та м'язова втома. Проаналізовані показники навантаження не показали достовірної кореляції з ушкодженням підколінного сухожилля. Таким чином, зв'язку між зовнішнім навантаженням і травмою підколінного сухожилля у професійних футболістів не встановлено.

Висновки. Логістична регресійна модель ($p > 0,05$) не продемонструвала статистичної значущості. Отже, жодна з досліджуваних змінних зовнішнього навантаження не пояснює частоту неконтактних травм підколінного сухожилля в цій категорії досліджуваних.

Ключові слова: індикатори зовнішнього навантаження, травма підколінного сухожилля, система глобального позиціонування (GPS).

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