Study concerning the incidence of knee sprain and the biomechanical analysis during running at sportsmen who suffered from knee sprain

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***Abstract*—Introduction**: In the field of sports traumatology, the knee sprain represents one of the most frequent injuries, with particular implications in what the performances of the sportsmen are concerned, the inactivity period and the recovery process of these sportsmen. Knee sprain is the main cause of inactivity at athletes. This type of injury occurs more frequently in team sports like: football, basketball, handball or rugby. This frequency is also influenced by field surface, physical state, the non-compliance to diet and medication.

Purpose of the study: The aim of this study was the analysis of the biomechanical characteristics of the knee joint in sportsmen who experienced knee sprains, of I and II degree. The analysis of the recordings made during the study, indicated the occurrence of some modifications and therefore we could evaluate the efficiency of the kinetic programme the subjects underwent.

Subjects and method: For a total of 88 recorded cases of knee sprains the ratio men/women was 5.76 and the maximum incidence (71.58%) was between 21-30 years. The most frequent injuries were those affecting the ligaments, 64.77% (57 cases), followed by injuries of the meniscus, 35.22% (31 cases). The present study comprises just 18 sportsmen selected from the 88 analysed. These sportsmen experienced a knee sprain, of I and II degree, and besides the speciality treatment, they followed a recovery period consisting in individualised kinotherapy. The age group distribution was the following: 19-25 years-14 sportsmen, 26-30 years - 1 sportsman, 31-35 years - 3 sportsmen. Out of the 18 subjects, 13 were male and 5 female. The duration of the research study was 4 years. The cinematic analysis of the joints of the lower limb was made with the use of the CMS Zebris system. The biomechanical modifications found in the knee joint were monitored while running on a flat surface and on a rolling carpet, at the end of the recovery period**.**

Results and interpretation of results: The analysis of the recordings made during the study, was done in order to investigate the running biomechanical characteristics. All the sportsmen who were recruited in this study were proved to have an associated laterality movement, caused by ligament laxity, secondary to knee sprain.

Conclusions: The analysis of the gathered data proved the existence of some high values of ligament laxity in 6 sportsmen, with the following age distribution: 2 cases -21 years, 3 cases -30/35 years, 1 case -25 years.

***Keywords*—**laxity, sprain, knee, ligament, running

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I. INTRODUCTION

IN the field of sports traumatology, the knee sprain represents one of the most frequent injuries, with particular implications in what the performances of the sportsmen are concerned, the inactivity period and the recovery process of these sportsmen. Worldwide studies reveal very high costs for recovering athletes with various injuries. Egger G estimates that each year, over 1 billion dollars is spent for the recovery of the sportsmen [1].

II. OBJECTIVE

The aim of this study was the analysis of the biomechanical characteristics of the knee joint in sportsmen who experienced knee sprains of I and II degree. The analysis of the recordings made during the study, indicated the occurrence of some modifications and therefore we could evaluate the efficiency of the kinetic programme the subjects underwent.

III. SUBJECTS AND METHOD

The frequency of accidents is quite high in team sports, because of the numerous physical contacts and of sudden change of moves.

Table 1 - Distribution of cases depending on sports branches

Sport	No. of sprains	Percentage
football	41	46.59%
handball	31	35.23%
basketball	7	7.95%
rugby	6	6.82%
voleyball	3	3.41%
Total	88	100%

The frequency of accidents is higher in those athletes that have started practicing sports from childhood and in time, they developed joint problems because of long-time effort, sports grounds unfit for technical conditions required, overtax in competition periods, most frequently the lack of adequate medication and diet required for that type of effort.

Table 2 - Distribution of cases depending on age groups

Age group	No. of cases	Percentage
17 – 20 years	9	10.23%
21 – 25 years	36	40.91%
26 –30 years	27	30.68%
31 –35 years	16	18.18%
Total	88	100%

The gender distribution was: females 13 cases, 14.77%; males 75 cases, 85.23%, with a male to female ratio of 5.7.

Table 3 - Distribution of cases depending on age groups

Injury	Nr. of cases	Percentage
meniscus	31	35.23%
collateral ligaments	23	26.14%
cruciate ligaments	34	38.64%
Total	88	100%

A. Meniscus Injuries

From the total of 88 cases of sprain injuries, meniscus injuries were 31 cases (35.23%), from which 4 cases were relapses (12.90%).

There were 20 cases with internal meniscus injuries, 64.52% from all cases of meniscus injuries and 22.73% from all types of sprains. Three cases of relapse were found (15.0% from 20 cases with internal meniscus injuries; 9.68% from 31 meniscus injuries and 3.41% from 88 sprains). There were 11 athletes with external meniscus injuries (35.48% from 31 meniscus injuries and 12.50% from 88 sprains), one of them was relapse (9.09% from those 11 athletes with external meniscus injuries, 3.23% from 31 cases with meniscus injuries and 1.14% from 88 sprain cases).

B. Ligaments Injuries

From the 88 sprain cases, 57 (64.77%) had ligament injuries, from which 11 (19.30%) were relapses. In this subgroup 23 sportsmen had collateral ligaments injuries and 34 had cruciate ligaments injuries.

C. Collateral Ligaments Injuries

A total of 23 cases of such type were met (40.35% from 57 ligament injuries and 26.14% from 88 sprains). There were 14 cases of internal collateral ligaments injuries representing 60.87% from 23 collateral ligaments injuries, 24.56% from 57 sprains with ligament injuries and 15.91% from 88 sprains. The 3 detected relapses are 21.43% from internal collateral ligament injuries, 13.04% from collateral ligament injuries, 5.26% from ligament injuries and 3.41% from sprains.

On the other hand there were 9 cases of external collateral ligament injuries representing 39.13% from 23 cases with sprains associated with collateral injuries, 15.79% from 57 sprains with ligamental injuries and 10.23% from 88 sprains. Only one relapse has been met for this injury type. This relapse is 11.11% from external collateral injuries, 4.35% from collateral ligament injuries, 1.75% from ligamental injuries and 1.14% from sprains.

D. Cruciate Ligaments Injuries

From the total of 88 cases of sprain injuries, 34 cases were cruciate ligaments injuries (that is 59.65% from the 57 ligamental injuries and 38.64% from the 88 sprains).

There were 25 cases of anterior cruciate ligaments injuries representing 73.53% from the 34 sprains with cruciate ligament injuries, 43.86% from the 57 ligament injuries and 28.41% from the total of 88 sprains.

We had 13 relapses in anterior cruciate ligaments injuries that is 52.00% from anterior cruciate ligaments, 38.24% from cruciate ligament injuries, 22.81% from ligament injuries and 14.77 % from sprains.

9 cases of posterior cruciate ligaments injuries were met, which means 26.47% from the 34 cruciate ligament injuries, 15.79% from the 57 ligamental injuries and 10.23% from the 88 sprains.

The 4 detected relapses are representing 44.44% from posterior ligamental injuries, 11.76% from cruciate ligament injuries, 7.02% from ligamental injuries and 4.55% from the total sprains.

Just a group of 18 sportsmen agreed to participate at the study concerning biomechanical analysis of running.

During the years 2004-2008, we have analysed the biomechanical characteristics of the knee joint of these 18 sportsmen who experienced sprains at this level. They followed the specialised treatment and kinetotherapy associated with other complementary methods for recovery [2], [3]. The age distribution was the following: 19-25 years - 14 subjects, 26-30 years -1 subject, 31-35 years -3 subjects. Out of these, 13 were male and 5 female. Depending on the sports they practiced, we selected the sportsmen who practiced handball and football, since we noticed along the years that these sports have a higher incidence of knee sprains in comparison with other individual sports. The study included 11 handball and 7 football players.

The cinematic study of the lower limb joints was performed using the Zebris CMS system consisting in a data acquisition station from a system with attachable sensors and the corresponding software for the processing of the acquired data. The system is based on the emission and reception of ultrasound waves [4], [5], [6]. The sensors are placed on the lower limb at the thigh, the knee, and on the plantar region, in order to cover the entire range of movements of the lower limb joints. The present study consists only in the analysis of the movements of the knee joint, while running on a flat surface and on a rolling carpet.

The report generated by the WinGait software, based on the acquired data, takes into consideration the duration of a running cycle of approximately 1.6 seconds. Therefore, the interval during which the measurements were made, is divided into sub-intervals with a duration of 1.6 seconds, resulted from the periodicity of the measured quantities

IV. RESULTS

By using this system, we made a biomechanical analysis of the movements of the knee in the following running conditions: flat surface running and running on rolling carpet. For these tests, we have selected only the sportsmen who practiced football and handball, because, based on our research, we reached the conclusion that the highest incidence of knee sprains occurs in these two sports. Eighteen performance sportsmen took part in this study, out of which 4 are national league sportsmen and 14 are sportsmen in national divisions A, B, and C.

The programme recorded the flexion movement, by measuring the angle formed by joining with straight lines the middle of the side part of the knee joint with the lateral malleolus and with the greater trochanter of the femur. In the recording, the positive values refer to the flexion movement, and the negative ones to the extension movement. The lateral movement of the knee occurs because of the laxity, which is maintained at the knee level. The program defines it as lateral movement and the terminology is kept in the graphs and in the tables, which are the results of the data processing of this programme. The negative value indicates an outward displacement during the test sequences of running on a flat ground and running on rolling carpet- in the knee joint and the positive value indicates an inward displacement towards the vertical axis, which represents the reference axis for the measurements. The outward displacement is visible in all recordings, and is more obvious in the recently injured lower limb. But in certain sportsmen, it can be seen on both sides due to the high incidence of accidents involving the knee joint. The lateral movement can be seen even if the sportsmen followed the recovery programme and function to its values and the biomechanical sequences of the movement in which occurs, is continued the specific recovery programme. The testing was repeated 3 times every other month, in order to observe the modifications which occurred in the different biomechanical stages of the running. Based on these recordings, an individual physical training programme was determined for each sportsman.

In the case of sportsman B.A., aged 22, the present injury is in the right knee, where the lateral movement is maintained during all the studied stages, but it is obvious during the running sequence, where the values are: -7.31±3.54. This subject also presents with a latent laxity in the left knee, as a result of a previous injury and the values are -0.94±7.37 for running on rolling carpet, significant lower than those recorded in the right knee.

Sportsman P.A., aged 21, had modifications of the angles in the right knee, with values significantly lower than the initial evaluations, but present during all the running sequences studied, i.e. -2.68±4.32, and running on rolling carpet -3.97±7.64.

Sportsman C.A., aged 32, presented with bilateral laxity, as a consequence of a number of accidents suffered along his sports activity. The current injury is located in the left knee. A year ago he suffered a II degree knee sprain of the right knee. From a biomechanical point of view, this is illustrated by the persistence of ligament laxity, present in our recordings (in the left knee we found values of -3.47±3.57 during running and of -9.92±9.19 during running on rolling carpet). The values are lower than in the injured knee where they vary as follows: -7.29±3.03 for running and 9.41±6.64 for running on rolling carpet. These data point out a higher laxity during the movements with loading, which indicate the need to continue the recovery programme and the use of any kind of orthosis for any type of physical effort.

Subject M.M., aged 21, experienced a sprain of the right knee, with significantly high values in what the lateral movement was concerned and with a slight compensation by the muscular activity for the movement sequences made on slant plans, i.e. running on rolling carpet -7.36±8.39, compared to running on a flat surface -13.73±14.28. Tapping and orthosis are indicated.

In sportsman C.N., aged 35, we could notice the presence of a slight laxity of the right knee. He experienced 3 years ago a sprain and the relatively close values for all types of movements tested for the left knee, the one with the most recent injury, are: running -5.08±4.36, running on rolling carpet -5.93±5.87. These values are significantly lower than those determined in previous tests.

O.M, aged 26, had an almost equal bilateral laxity, the most recent injury being in the left knee, and the right one experiencing minor injuries in the previous years. On the recordings of the left knee movements we could notice a higher laxity during the movements on a flat surface. The movement is partially compensated by the contraction of the musculature while running on a slant plan, i.e. 4.41±8.40 and on running on a rolling carpet -2.35±7.68.

S.A., aged 24, has modifications in both joints, the most recent accident being in the left knee. The values do not show any compensation by muscular activity during the effort with a counter resistance movement: running -7.66±8.78 and running on rolling carpet -8.97±5.46.

We can notice in sportsman T.C., aged 24, an obvious decrease of the values as compared to the ones of the previous recordings, which indicates the fact that the recovery programme is effective. The values -0.79±6.38 for running are the lowest values obtained in the study group.

I.S., aged 21, has a modification of the recordings in both knee joints. In the right knee, where the sprain is more recent, we could notice a very slight alteration of the values as compared to the previous recordings, with a lack of compensation for the movements on the carpet. In this case, the sportsman has not been yet integrated in the activity of the team, but he continues the individual programme until a new check-up. The laterality movement in the right knee has the following values: running -15.75±2.88 and running on rolling carpet -16.10±6.49.

Table 1 - Personal information, sports practiced, type of sprain, generation mechanism and treatment followed

No.	Name, first name (initials)	Age	Sex	Sport practiced	Diagnosis	Generation mechanism	Treatment
1.	O.M	26	M	Football	Sprain I degree	Traumatism	Orthosis kinetotherapy
2.	B.A.	33	F	Handball	Sprain II degree	Traumatism	Immobilisation 21 days, Kinetotherapy
3.	C.A.	25	F	Handball	Sprain II degree	Traumatism	Immobilisation 21 days, Kinetotherapy
4.	I.M	21	F	Handball	Sprain I degree	Compressive force	Tapping kinetotherapy
5.	I.S	21	M	Handball	Sprain I degree	Compressive force	Tapping kinetotherapy
6.	B.A.	22	M	Handball	Sprain I degree	Compressive force	Tapping kinetotherapy
7.	B.A.	21	M	Handball	Sprain II degree	Complex	Immobilisation 21 days, Kinetotherapy
8.	C.M	21	M	Handball	Sprain II degree	Traumatism	Orthosis kinetotherapy
9.	C.C.	20	M	Football	Sprain I degree	Compressive force	Tapping kinetotherapy
10.	R.D.	22	M	Football	Sprain I degree	Traumatism	Orthosis kinetotherapy
11.	S.A.	24	F	Handball	Sprain II degree	Repeated compressive forces	Immobilisation 14 days, Kinetotherapy
12.	T.C.	24	F	Handball	Sprain I degree	Compressive force	Tapping kinetotherapy
13.	C.N.	35	M	Handball	Sprain II degree	Complex traumatism	Arthroscopy kinetotherapy
14.	C.A.	32	M	Handball	Sprain II degree	Complex	Immobilisation 21 days, Kinetotherapy
15.	M.M.	21	M	Football	Sprain II degree	Compressive force	Immobilisation 21 days, Kinetotherapy
16.	P.A.	21	M	Football	Sprain I degree	Traumatism	Tapping kinetotherapy
17.	S.R.	22	M	Football	Sprain I degree	Traumatism	Tapping kinetotherapy
18.	T.S	24	M	Football	Sprain II degree	Repeated compressive forces	Immobilisation 14 days, Kinetotherapy

In the case of patient I.M., aged 21, there is a high bilateral ligament laxity, which is maintained also after the completion of the individual recovery programme. The compulsory use of an orthosis for any type of physical effort and the continuation of the recovery programme with a subsequent recording of the movements for both knees after another interval of 2 months were recommended. In this case, an individual training was preferred to the specific team training programme. The values recorded at the latest medical check-up were as follows: left knee with recent sprain: running -19.42±11.52, running on rolling carpet -17.59±3.19; right knee - where the sprain is older, but the recovery was neglected, running -10.04±2.66, running on rolling carpet -8.16±6.17. In the latter we could notice a slight compensation by muscular activity, during the movements made on the carpet, which were also with loading. These higher values may also be explained by the fact that the sportsman did not follow strictly the recommended recovery programme.

In sportsman B.A., aged 33, the values are still high in all the studied sequences for the right knee. After the completion of the recovery programme, the results are: for running -14.03±3.76 and for running on rolling carpet -13.66±6.09. The continuation of the individual physical training is recommended, but without restarting the specific effort for the practiced sport.

In the recordings of sportsman T.S., aged 24, we could notice variations in both knees, with values obviously higher on the right, treated knee. The obtained values indicated an instability increase for movements on the carpet, compared to those made on a flat surface. For this reason we recommended the continuation of the individual physical training, combined with the compulsory wearing of the orthosis. The recordings indicated: running -10.85±2.19 and running on rolling carpet -14.71±8.74.

The patient S.R., aged 22, presented a decrease of the values obtained in the previous measurements, but with the persistence of some relatively high values, in the right knee and with a slight compensation during the counter resistance movement, which led to the recommendation for the continuation of the individual programme with gradual reintegration into the team activity. For the right knee the values are: running -9.13±2.61 and for running on rolling carpet -7.01±5.46.

The sportsman B.A., aged 21, presents minor modifications compared to the previous recordings, with a slight compensation during running on carpet, which made us recommend the continuation of the recovery with the intensification of the counter resistance movements.

Table 2 - Movement recordings in the knee while running

Name, age	Laterality Right knee medium ± standard deviation (M ± SD); (no.)	Laterality Left knee medium ± standard deviation (M ± SD); (no.)	Statistical significance "p"	Interpretation	Flexion Right knee medium ± standard deviation (M ± SD); (no.)	Flexion Left knee medium ± standard deviation (M ± SD); (no.)	Statistical significance "p"	Interpretation
B. A., 22 years	-7.31±3.54; (48)	2.38±5.48; (54)	p < 0,0001	ES	52.18±14.70; (48)	152.45±15.16; (54)	p < 0.0001	ES
P. A., 21 years	-2.68±4.32; (57)	2.90±9.99; (55)	p = 0.0002	ES	46.69±12.66; (57)	38.65±57.16; (55)	p = 0.3008	NS
C. A., 32 years	-3.47±3.57; (68)	-7.29±3.03; (66)	p < 0.0001	ES	38.81±15.28; (68)	31.60±22.53; (66)	p = 0.0328	S
M. M., 21 years	-13.73±14.28; (53)	-3.51±3.08; (52)	p < 0.0001	ES	53.13±29.65; (53)	43.39±15.65; (52)	p = 0.0402	S
C. N., 35 years	1.39±4.61; (41)	-5.08±4.36; (40)	p < 0.0001	ES	40.06±17.25; (41)	43.17±16.37; (40)	p = 0.4139	NS
O. M., 26 years	-4.22±5.08; (52)	-4.41±8.40; (53)	p = 0.8901	NS	41.14±17.52; (52)	33.13±52.27; (53)	p = 0.3015	NS
I. M., 21 years	-10.04±2.66; (59)	-19.42±11.52; (67)	p < 0.0001	ES	33.35±20.21; (59)	27.34±27.68; (67)	p = 0.1750	NS
T. C., 24 years	-4.56±4.20; (54)	-7.39±6.85; (53)	p < 0.0001	ES	38.26±19.87; (54)	33.59±29.13; (53)	p = 0.3247	NS
B. A., 33 years	-14.03±3.76; (65)	-2.81±9.55; (61)	p < 0.0001	ES	38.63±20.25; (65)	41.36±39.36; (61)	p = 0.6250	NS
S. A., 24 years	-2.07±3.41; (71)	-7.66±8.78; (69)	p < 0.0001	ES	34.05±16.50; (71)	38.57±33.22; (69)	p = 0.7330	NS
C. A., 25 years	-10.84±5.99; (64)	-8.49±8.74; (67)	p = 0.0786	NS	35.57±32.95; (64)	38.33±33.25; (67)	p = 0.6368	NS
T. S., 24 years	-10,85±2,19; (72)	-9.57±1.85; (63)	p = 0.0004	ES	44.87±17.49; (72)	52.41±16.46; (63)	p = 0.0120	S
S. R., 22 years	-9.13±2.61; (84)	-3.46±6.12; (93)	p < 0.0001	ES	27.49±17.22; (84)	36.58±30.25; (93)	p = 0.0171	S
C. C., 20 years	-1.66±5.08; (63)	-3.43±3.96; (60)	p = 0.0352	S	39.30±30.62; (63)	38.3±18.13; (60)	p = 0.8284	NS
B. A., 21 years	-11.51±12.79; (80)	-4.30±7.56; (80)	p < 0.0001	ES	29.58±40.43; (80)	21.90±14.48; (80)	p = 0.1140	NS
I. S., 21 years	-15.75±2.88; (38)	-8.93±6.30; (53)	p < 0.0001	ES	44.33±20.82; (38)	37.28±28.13; (53)	p = 0.1996	NS
R. D., 22 years	8.80±6.06; (29)	-	p < 0.0001	ES	42.41±16.98; (29)	40.04±20.59; (32)	p = 0.6336	NS
C. M., 21 years	3.59±11.26; (75)	-9.09±8.60; (100)	p < 0.0001	ES	34.71±46.66; (75)	36.69±21.97; (100)	p = 0.0711	NS

The values in the right knee for running on the rolling carpet are -10.07±5.24.

C.C., aged 20, has bilateral modifications, which in the case of the right knee (the one with an older injury) compensate very well, whereas in the case of the left knee, where the injury is recent, we could notice a lack of muscular compensation for movements made on the carpet. That is why we recommended the modification of the recovery program by introducing the loading exercises, in order to increase the stability of the left knee: running -3.43±3.96 and running on rolling carpet 8.48±4.76.

C.A., aged 25, has bilateral alterations, namely the left knee, where the injury is older, compensated during counter resistance movement, running -8.49±8.74, and running on rolling carpet -4.68±4.25. In the knee with the recent sprain, the values are almost similar, but with a significant increase during running on carpet, which indicates a higher instability for this type of effort: running -10.84±5.99 and running on rolling carpet -18.63±8.33.

R.D., aged 22, presents a significant decrease of the recorded values for the laterality movement of the left knee while running on the carpet, which indicates an effective muscular contraction with the possibility of reducing the values for other types of movements, as well. The comparative values are: running -6.88±2.49 and running on rolling carpet -2.73±4.34.

The sportsman C.M., aged 21, has been determined with still high values in the left knee, during the recordings made on flat surface, i.e. running -9.09±8.60. In the right knee, we could notice a decrease of these values during the counter resistance movement sequences: running on rolling carpet -5.45±6.65, which indicates a positive outcome.

I.A., aged 21, is the sportsman who did not take part in the scheduled evaluations. In this case, we noticed the presence of

Table 3 - Movement recordings in the knee while running on rolling carpet

Name, age	Laterality Right knee medium ± standard deviation (M ± SD); (no.)	Laterality Left knee medium ± standard deviation (M ± SD); (no.)	Statistical significance "p"	Interpretation	Flexion Right knee medium ± standard deviation (M ± SD); (no.)	Flexion Left knee medium ± standard deviation (M ± SD); (no.)	Statistical significance "p"	Interpretation
B. A., 22 years	11.99±6.75; (323)	-0.94±7.37; (372)	p < 0.0001	ES	73.37±23.30; (323)	62.65±20.31; (372)	p < 0.0001	ES
P. A., 21 years	-3.97±7.64; (916)	3.47±8.23; (757)	p < 0.0001	ES	61.33±18.72; (916)	64.68±19.59; (757)	p = 0.0004	ES
C. A., 32 years	-9.92±9.19; (541)	-9.41±6.64; (588)	p = 0.2831	NS	50.63±20.75; (541)	50.66±17.98; (588)	p = 0.9793	NS
M. M., 21 years	-7.36±8.39; (822)	0.82±8.28; (830)	p < 0.0001	ES	74.84±20.65; (822)	69.35±17.35; (830)	p < 0.0001	ES
C. N., 35 years	-1.38±5.87; (792)	-5.93±5.87; (628)	p < 0.0001	ES	61.60±24.41; (792)	51.85±21.89; (628)	p < 0.0001	ES
O. M., 26 years	-3.93±7.69; (1096)	-2.35±7.68; (937)	p < 0.0001	ES	63.69±24.65; (1096)	56.61±21.09; (937)	p < 0.0001	ES
I. M., 21 years	-8.16±6.17; (1065)	-17.59±3.19; (1035)	p < 0.0001	ES	57.41±24.88; (1065)	53.84±24.69; (1035)	p < 0.0001	ES
T. C., 24 years	2.24±6.40; (1809)	-0.79±6.38; (937)	p < 0.0001	ES	62.56±19.90; (1809)	56.72±24.46; (937)	p < 0.0001	ES
B. A., 33 years	-13.66±6.09; (1237)	-1.05±6.33; (1044)	p < 0.0001	ES	55.68±25.44; (1237)	50.60±21.97; (1044)	p < 0.0001	ES
S. A., 24 years	-4.69±9.02; (1265)	-8.97±5.46; (1280)	p < 0.0001	ES	53.56±24.16; (1265)	47.22±21.42; (1280)	p < 0.0001	ES
C. A., 25 years	-18.63±8.33; (983)	-4.68±4.25; (827)	p < 0.0001	ES	59.02±27.59; (983)	57.79±23.50; (827)	p = 0.1557	NS
T. S., 24 years	-14.71±8.74; (1167)	-4.55±8.05; (832)	p < 0.0001	ES	84.96±24.49; (1167)	79.07±26.94; (832)	p < 0.0001	ES
S. R., 22 years	-7.01±5.46; (1810)	-3.93±8.97; (1523)	p < 0.0001	ES	41.41±19.15; (1810)	52.25±20.66; (1523)	p < 0.0001	ES
C. C., 20 years	4.84±3.12; (253)	-8.48±4.76; (257)	p < 0.0001	ES	73.74±15.04; (253)	64.98±21.17; (257)	p < 0.0001	ES
B. A., 21 years	-10.07±5.24; (256)	0.66±12.54; (278)	p < 0.0001	ES	47.65±17.49; (256)	46.73±20.05; (278)	p =0.5745	NS
I. S. , 21 years	-16.10±6.49; (496)	-4.19±7.11; (489)	p < 0.0001	ES	66.03±21.82; (496)	62.18±17.05; (489)	p = 0.0021	FS
R. D., 22 years	3.53±10.39; (229)	-	p < 0.0001	ES	48.99±15.79; (229)	44.98±23.49; (159)	p = 0.0456	S
C. M., 21 years	7.12±5.21; (993)	-5.45±6.65; (738)	p < 0.0001	ES	63.73±17.03; (993)	57.35±17.39; (738)	p < 0.0001	ES

internal laxity in the right knee (19.30±14.64), in comparison with the healthy knee (left 7.49±8.32) and with the recordings of the other sportsmen. There could be no evaluation for this subject because of his lack of seriousness concerning the recovery schedule.

V. Discussions

The knee traumatology represents one of the most important chapters of sports traumatology with special implications on future sports activity.

The injuries of the lower limb represent a vast majority [7], [8], [9]. At the knee level 39% of injuries are ligament injuries but not ruptures and 75% are located at the medial collateral ligament level [10].

Price RJ concludes, based on a study done at several football clubs from Great Britain, that sprains represent 31% of all sports injuries [11].

The Hawkins study revealed that 19% of injuries appear during running, 8% of injuries during sudden twisting and turning, 4% of injuries after hitting the ball, and 4% after landing [10].

Powell and Arnason [11], [12] state that the incidence of injuries in terms of using synthetic surfaces is 2 times greater compared with the injuries that occur in sportsmen performing on grass. It seems that the rigidity of the surface produces an increase of the force applied to the tissues involved in these injuries (articular soft tissues). The rigidity of the playing surface leads to an increase of friction that occurs during the start, the sudden stops and swivels. This combination of friction – playing surface increases the incidence of injuries during sports activity and may explain the large number of non-contact injuries.

The highest incidence of sprains occurs in athletes aged 21-25, in full performance and especially to those who have started sports in childhood, due to overloading.

This is explained by the sustained physical effort for a long time starting as child and without appropriate diet and effort medication. Hall S claims that the occurrence mechanism for these injuries is probably multifactorial.

Hence he states that the inadequate muscle development during adolescence makes the absorption of the inherent shocks impossible [13].

Authors like Ekstrand and Gillquist highlight an incidence of relapses of 25.8%, out of which 10.5% are located in the same joint. These authors explain that the main cause that leads to relapses is ligament laxity. In their study group, 24% of the sportsmen with relapses had articular laxity.

The study led by Chomiak shows that 23.24% of the sportsmen who suffer a sports traumatism had a preexistent injury in the last 12 months.

Ekstrand [15] and Orchard [15] report a percentage of 17% and Nielsen and Yde [16] report a frequency of 25% of the relapses.

Pehoiu [17] revealed that 11-26% of injuries appear due to poor hygienic condition of sports equipment, sportsmen clothing or footwear. This author has shown that temperature, low humidity, unsatisfactory lighting, noise or contaminated air are causes for 2-6% of injuries.

Knee ligaments provide stability and resprain knee motion in more than one degree of freedom, while the overall joint stability depends on the contributions of the individual ligaments and their interactions according to Haghpanahi [18]. The author has shown that the fully understanding of the role of each individual ligament in motion restraining is essential for the development of an adequate diagnostic and assessment on surgical procedures. A proper understanding of knee joint biomechanics is therefore essential to improve the prevention and treatment of its disorders and injuries states Yuhua Sorg [19].

A study similar to the one described in our paper, based on simultaneously recording of rowing kinematics in sagittal plane and muscle EMG activity was done by Ante Panjkota [20]. The same author states that in the last few years, human motion analysis is one of the most studied fields in the science. Especially in sports large scientific attention has been paid to human movement in order to improve the performance and specific sport technique, as well as to prevent the injury [21].

VI. CONCLUSIONS

In our study group we noticed a high frequency of knee sprains during contact sports.

We found a higher frequency of knee sprains in sportsmen with ages raging from 21-30, which is consistent with the data in the literature.

A progressive and gradual resumption of physical effort under the supervision of a sports medicine specialist, a medical recovery specialist, and of a kinetotherapist is extremely important.

There are cases in which the amplitude of the movements of the knee is never completely regained.

If the injuries are not serious a short period of immobilisation and associated isometric contractions throughout this period, followed by an immediate recovery in a specialised center is recommended.

The kinetic treatment will be tailored individually for each sportsman with an immediate onset, when possible and it should be continued after the resumption of sports activity, in order to prevent other possible relapses.

By analysing the locomotory characteristics of the knee joint, we have noticed the presence of a laterality movement, which, in some sportsmen, was enhanced during all types of running, whereas in other sportsmen only for movements performed on the inclined plane.

By conducting evaluations at certain intervals, determined according to the severity of the injury and its progress, and from the analysis of obtained data, we were able to adjust the recovery program based on the individual features of the sportsman.

Based on the biomechanical analysis, we noticed the existence of higher values of ligament laxity in 6 of the 18 cases, distributed as follows 2 cases are 21 years, 3 are in the age group 30-35 years and 1 case is 25 years old.

Also, we have noticed the existence of a remnant laxity, explained by the presence of older sprains in 2 sportsmen: C.A. aged 25, left knee running values -8.49±8.74, running on rolling carpet values -4.68±4.25 and I.M., aged 21, right knee running values -10.04±2.66 and running on the rolling carpet values -8.16±6.17.

We also had a sportsman who did not complied with the recommended recovery program and for him we have noticed higher values of ligament laxity, as compared with the assessments made for other sportsmen after the same recovery interval. This is sportsman: I.M., aged 21, left knee running values 9.42±11.52 and running on the rolling carpet values -17.59±3.19.

For sportsman T.C., aged 24, who still presented small negative values for running -0.79±6.38, we have noticed the best outcome after the recommended treatment.

In order to have a biomechanical assessment of all joints for performance sportsmen, this recording would be useful to all sportsmen, regardless of whether or not they suffered an injury, but only to have a reference point for an eventual injury and to assess the favourable or unfavourable outcome in case of an injury.

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