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Original Research

Is There an Association Between Injury History and Lower Extremity Joint Injury During Canada Games Competition?

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Background

Injuries during elite level competition like the Canada Games, occur frequently and injury history is one of the strongest predictors of future injury; however, this association is unknown in the Canada Games.

Purpose

To determine the association between injury history and incidence of lower extremity joint injury during Canada Games competition.

Methods

Data from the 2009 – 2019 Canada Games (8710 male and 8391 female athletes) competitions were de-identified by the Canada Games Council for analysis. Injury data were cleaned and categorized for previous injury and injury type and location. Injury history was self-reported and included concussion, major surgical procedure, neck and back, trauma to joint or bone, and trauma to ligament or tendon. Injury from the Canada Games competitions were categorized to include ankle, knee, hip, and patellofemoral joint injuries. Chi-Square (χ^2) test of independence determined association between injury history and incidence of lower extremity joint injury during Canada Games competition. IBM SPSS (Version 26) was used for statistical analysis (p-value < 0.05).

Results

Four hundred and seventy-five ankle, 503 knee, 253 hip, and 106 patellofemoral joint injuries were reported during 10 years of Canada Games competitions. There were significant associations between history of neck and back injuries with ankle injuries and knee injuries, history of trauma and overuse of ligament or tendon with hip injuries and history of trauma or overuse of joint or bone with patellofemoral joint injuries.

Conclusion

These findings support previous literature suggesting that injury history is associated with future injury.

Level of Evidence

3

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INTRODUCTION

The Canada Games competition is the highest level of competition where amateur Canadian athletes can showcase their skills and talents during various events while competing against other athletes from other provinces or territories. These athletes must train for many years to qualify for the Canada Games, which may result in injuries that can be due to overtraining, inadequate nutrition, insufficient recovery, and poor technique.[1,2] Previous studies have noted that injury history is considered one of the strongest predictors of future injury in athletes.[3,4] For example, in Australian football players Orchard et al[5] reported that previous injuries increased the risk of sustaining a muscle strain at the same location in the hamstrings, as well as in the quadriceps and calf muscles, using an observational cohort studying 5 high school sports over 3 years. Rauh et al[6] found that previous injuries increased the risk of future injuries at the same location as the prior injury as well as to different regions. This relationship between injury history and future injury may be attributed to deficits in muscular strength, proprioception, altered movement patterns, reduced range of motion (ROM), and accumulation of scar tissue.[2,7]

Lower extremity injuries in an active, healthy adult population lead to intrinsic changes at the initial point of injury, which may contribute to increase risk of future injury.[8] For example, having previous knee joint trauma has been associated with a two-to-three-fold increase in risk of future knee injury.[9] Many recurrent injuries can be attributed to inadequate rehabilitation and premature return to play; however, some injuries may increase the risk of re-injury regardless of time interval between initial injury and future injury.[7] Further, regional interdependence is an important factor of how movement occurring within the kinetic chain can contribute to future reinjury specifically to the lower extremity.[10]

The lower limb is the most common anatomical site injured among Olympic-level athletes with ankle and knee injuries reported most commonly amongst British and US athletes.[11,12] Ankle injuries are said to be one of the most commonly reported injuries in sports, including soccer, basketball, football, and volleyball.[13,14] Athletes who suffer an ankle injury can have symptoms such as mechanical instability, stiffness and swelling, and cartilage damage which can lead to degenerative changes.[15] At the knee, anterior cruciate ligament injury (ACL) is the most common knee injury reported in athletes[16]; this injury can be detrimental to athletes because of post injury altered gait and knee kinematics, muscle weakness, and deficits in functional assessments, which are associated with long-term risk of meniscal tears, osteoarthritis, and chondral lesions.[17-19] Further, the prevalence of patellofemoral joint injury is high and it mainly impacts athletes with no structural abnormalities.[20] Rathleff et al[21] reported that 25% of recreational athletes with patellofemoral joint injuries stopped participating in sports due to knee pain. Other lower extremity injuries such as those to the hip are also problematic in athletes as these have been associated with decline in athletic performance in various sports due to factors such as weaker hip adductor muscles, age, and ROM deficits.[22] Multiple authors have noted that history of injury can increase risk of lower extremity joint injuries.[1,2,23] However, the association between injury history and lower extremity joint injury is still unknown in the Canada Games.

Therefore, the purpose of this study was to examine the association between injury history and lower extremity joint injury during the Canada Games Competition between 2009-2019. The authors hypothesized that there would be a significant association between injury history and lower extremity joint injury across 10 years of Canada Games competition.

METHODS

STUDY DESIGN

This research study was a retrospective cohort design that assessed the association between injury history and incidence of lower extremity joint injury during the Canada Games competition between 2009-2019.

PARTICIPANTS

Seventeen thousand, one-hundred and one athletes competed in the Canada Games over 10 years of competition (8710 males and 8391 females). For the purposes of this study, the authors focused on lower extremity joint injury and examined reports of ankle, knee, hip, and patellofemoral injuries from a larger sample in which the descriptive epidemiology of Canada Games data were determined.[24]

PROCEDURES

This secondary analysis of data was approved by the Brock University Ethics Board. Following approval, the Canada Games Council provided anonymized data for any athletes seeking medical attention during competition; athletes competing in the Canada Games gave consent for their data to be used for research purposes. All athletes provided the Canada Games with their medical history from an intake form that was provided to the athletes from the Canada Games Council; this medical history asked athletes to self-report if they previously experienced any of the following: concussion, major surgical procedures, neck and back injuries, trauma to joint or bone injuries and trauma to ligament or tendon injuries. The medical history, as well as injury data for athletes seeking medical attention, were provided to the researcher in a de-identified manner and included information such as, injury history, injury assessments, injury location and type of injury for each injury assessments.

Previous injuries (medical history) were then categorized and coded for concussion, major surgical procedures, neck or back injuries, trauma to joint and bone injuries and trauma to ligament or tendon injuries. For injuries incurred during the Canada Games competition, data were cleaned and coded in a descriptive epidemiological study,[24] a fur-

ther subset of this dataset was used for this current analysis based on injury location (ankle, knee, hip and patellofemoral joint) and injury type (fractures, sprains, meniscus, contusion, tendinopathy, arthritis, and patellofemoral pain syndrome). Additionally, information on athlete's sex, province and sport were also provided. Data were inclusive of the Canada Games competition from 2009-2019.

Following categorization and coding of the data the total number of ankle, knee, hip, and patellofemoral joint injuries across 10 years of competition were determined using Microsoft Excel. Chi-Square test of Independence was performed to determine the association between injury history and lower extremity joint injury location and injury types. The statistical analysis was conducted using SPSS (IBM SPSS Version 26, Armonk, NY) and $p < .05$ indicated statistical significance.

RESULTS

The initial data consisted of 17101 athletes (8710 male; 8391 females) who competed in the Canada Games competition between 2009-2019. From the sample 475 ankle injuries, 253 hip injuries, 503 knee injuries, and 106 patellofemoral injuries that were categorized as fractures, sprains, meniscus, contusion, tendinopathy, arthritis, and patellofemoral pain syndrome were identified during Canada Games competitions between 2009-2019. From 2009-2019 there were 125 fractures, 477 sprains, 68 meniscus, 133 contusions, 106 tendinopathy, 36 arthritis, or 96 patellofemoral pain syndromes were identified involving lower extremity joint injuries (Table 2). The relationship between reported cases of history of injury categories and injuries to the lower extremity joints are indicated in Table 1; while Table 2 demonstrates the relationship between history of injury categories and reported injury type.

There was a significant association between history of neck and back injuries with ankle and knee injuries. There was also a significant association between history of trauma or overuse of ligament or tendon with hip injuries. History of trauma or overuse of joint or bone was significantly associated with patellofemoral joint injuries (Table 3). Ankle and knee injuries were six times more likely with prior neck and back injuries. Hip injuries were four times more likely with previous trauma or overuse of any ligament or tendon injuries and patellofemoral joint injuries were seven times more likely with previous trauma or overuse of joint or bone injuries (Table 3).

There was a significant association between history of major surgical procedures with meniscus injury. History of trauma or overuse of joint or bone injuries was significantly associated with contusion, tendinopathy, and patellofemoral pain syndrome. History of trauma or overuse of ligament or tendon was significantly associated with sprains (Table 4). Contusions were four and a half times more likely with a history of trauma or overuse of joint or bone injuries. Tendinopathy and patellofemoral pain syndrome were four and seven times more likely respectively, with trauma or overuse of any joint or bone injuries. Sprains were four times more likely with previous trauma or overuse of any tendon or ligament injuries (Table 4).

DISCUSSION

The purpose of this study was to determine the association between injury history and lower extremity joint injuries during the Canada Games competition from 2009-2019. The key findings from this study were (1) previous injuries such as previous neck and back injuries, trauma or overuse of any ligament or tendon, and trauma or overuse of any joint or bone were associated with lower extremity joint injury and (2) any prior major surgical procedure, trauma or overuse of any ligament or tendon, and trauma or overuse of any joint or bone were associated with sprains, meniscus, contusion, tendinopathy, and patellofemoral pain syndrome. These findings are consistent with previous literature suggesting that injury history may increase the risk of future injuries.[3,4,25,26] Multiple authors have suggested that re-injury can be attributed to neuromuscular factors that are present following initial injury.[27,28] Following injury, alterations occurring in overall strength, proprioceptive abilities, and kinematics impact motor and cognitive function, which may be potential risk factors for re-injury. These factors may suggest areas for clinicians to target through rehabilitation strategies aimed to mitigate the risk of re-injury and/or new future injury.

Neck and back injuries were associated with ankle and knee injuries across 10 years of the Canada Games competition. These findings are similar to those reported in collegiate athletes as a history of lower back pain is a strong predictor of knee, ACL and other ligamentous injuries.[29] The mechanisms behind this may include lower back pain resulting in alterations in trunk motor control, impaired postural control, delayed muscle latencies, and abnormal trunk muscle recruitment patterns.[30,31] Further, there is an established association between previous neck and back injuries with lower extremity joint injuries in varsity-level athletes, which may be attributed to patients with lower back pain adopting a trunk-flexed posture and moving with greater knee extension.[32] It is important to acknowledge that multiple authors have indicated a relationship between history of back injuries and hip rotation range of motion.[33,34] However, no association was present in this current study. This may be due to the type of movement patterns involved in various sports that places different stresses on the joints of the lower extremity or it could be related to a self-report bias of injury history that may be present in this current study. To the authors' knowledge, this study is the first to observe an association between previous neck injuries with ankle and knee injuries; however, because neck and back were grouped together it is possible that this association may be related to back injuries rather than neck injuries. Due to the retrospective nature of this study, the authors are unable to ascertain if previous injury history was related specifically to the neck or the back. Further investigation is needed to determine if there is a relationship between neck injuries and lower extremity

Table 1. Results from 2x2 Contingency Table from Chi-Square analysis examining injury history and lower extremity joint injury.

Injury History		Lower Extremity Joint Injury During Canada Games Competitions							
		Ankle		Hip		Knee		Patellofemoral	
		Y	N	Y	N	Y	N	Y	N
Head & Concussion Injuries	Y	25	57	17	65	32	50	8	74
	N	450	810	236	1024	471	789	98	1162
Major Surgical Procedure	Y	23	61	18	66	33	51	10	74
	N	452	806	235	1023	470	788	96	1162
Neck & Back Injuries	Y	20	17	8	29	7	30	2	35
	N	455	850	245	1060	496	809	104	1201
Trauma or overuse of Joint & Bone	Y	73	139	43	169	68	144	27	185
	N	402	728	210	920	435	695	79	1051
Trauma or Overuse of Ligament & Tendon	Y	88	130	30	188	81	137	17	201
	N	387	737	223	901	422	702	89	1035

*Y = Yes, N = No

*Y = Yes in both horizontal and vertical categories indicate having experienced both previous injury history on the vertical axis as well as experiencing an injury to the joint indicated on the horizontal axis, N = No in both the horizontal and vertical categories indicates not having experienced the previous injury on the vertical axis and the injury to the joint indicated on the horizontal axis. For example, in the upper left-hand box there were 25 participants who reported a history of a head and concussion injury and an ankle injury during competition, and there were 450 participants in the upper left hand box that did not report a history of a head and concussion injury; however, did experience an ankle injury.

joint injuries. If this relationship does exist, future research should consider the mechanisms that may contribute to the association between neck injuries and ankle and knee injuries.

Previous trauma or overuse to joint or bone was associated with patellofemoral joint injuries. Common risk factors for patellofemoral joint injury include training loads, movement technique, strength of lower extremity musculature, and type of footwear.[35,36] There is a paucity of literature linking an association between previous joint or bone injuries with patellofemoral joint injuries. However, one study suggested a relationship between injury history and patellofemoral joint injuries as patellar dislocation or subluxation and surgeries have been noted to increase risk of future patellofemoral injuries.[37] Previous authors have hypothesized that the mechanisms behind this association may be due to altered biomechanics, proprioceptive abilities, and neuromuscular control that may predispose an individual to future patellofemoral joint injuries.[38-40] In addition, individuals with patellofemoral pain often demonstrate hip weakness, suggesting an association may exist between hip strength and patellofemoral joint injuries.[41,42] Further investigation is needed to verify if altered biomechanics, proprioception, and neuromuscular control are the mechanisms for the association in this current study. Of note, one previous study indicated an association between major surgical procedures and patellofemoral joint injuries[23]; however, the current findings differ as there was no association between major surgical procedures and patellofemoral joint injuries. It is possible that variations in operational definitions between studies and/or a recall bias could have led to these differences. Additionally, foot abnormalities such as pes cavus are very common in athletes with patellofemoral joint injuries[43]; thus, it is possible that foot abnormalities may be one the factors behind the association between injury history and patellofemoral joint injuries. Other risk factors such as compressive instability, patellar trauma, soft tissue lesions, overuse syndromes, and osteochondritis may increase the risk of a patellofemoral joint injury suggesting an association with previous trauma or overuse of joint and bone injury.[38]

In this study, previous trauma or overuse of any ligament or tendon was associated with hip injuries. This is consistent with previous reports indicating that there is an association between injury history and hip injuries.[39] One study reported weakness in the hip abductor muscles in individuals with a history of ankle sprains this may suggest that weakness in hip stabilizing musculature resulting in joint deviations and decreased hip stability, was related to proximal kinetic chain maladaptation resulting from ankle ligamentous instability.[44] After lower limb ligamentous injuries, dynamic postural stability of the lumbopelvic complex decreases, which can increase the risk of hip injuries.[45] Athletes with prior ligamentous injury may experience sensory and motor behavior deficits, which have been attributed to the lack of connection between mechanoreceptors and nervous system restoration.[10] For example, deficits in knee joint position sense during passive and action range of motion have been observed with athletes with ACL injuries.[4] Researchers have speculated that decrease in hip musculature can contribute to faulty lower extremity mechanics during dynamic tasks.

The current findings of association between previous trauma or overuse of ligament or tendon injury and sprains are consistent with conclusions of multiple authors indicating that previous injuries were the most important risk factors for sprains.[46-48] For example, Bahr & Bahr[49] reported that there is a six-to-ten-fold increase in future ankle sprains with prior history of ankle injuries. Multiple

Table 2. Results from 2x2 Contingency Table from Chi-Square analysis examining injury history and injury type.

Injury History		Lower Extremity Joint Injuries During Canada Games Competition													
		Fracture		Sprain		Meniscus		Contusion		TP		Arthritis		PFPS	
		Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N
Head & Concussion Injury	Y	5	77	25	57	5	77	7	75	4	78	3	79	6	76
	N	120	1140	452	808	63	1197	126	1134	102	1158	33	1227	90	1170
Major Surgical Procedure	Y	6	78	23	61	9	75	8	76	9	75	1	83	9	75
	N	119	1139	454	804	59	1199	125	1133	97	1161	35	1223	87	1171
Neck & Back Injuries	Y	2	35	15	22	0	37	5	32	1	36	1	36	2	35
	N	123	1182	462	843	68	1237	128	1177	105	1200	35	1270	94	1211
Trauma or Overuse of Joint & Bone	Y	18	194	74	138	6	206	13	199	24	188	6	206	25	187
	N	107	1023	403	727	62	1068	120	1010	82	1048	30	1100	71	1059
Trauma or Overuse of Ligament & Tendon	Y	17	201	91	127	11	207	16	202	20	198	7	211	18	200
	N	108	1016	386	738	57	1067	117	1007	86	1038	29	1095	78	1046

*Y= Yes, N = No,

*Yes, in both horizontal and vertical categories indicates having experienced both previous injury history on the vertical axis as well as experiencing injury type indicated on the horizontal axis, N = No in both the horizontal and vertical categories indicates not having experienced the previous injury on the vertical axis and injury type indicated on the horizontal axis. For example, in the upper left hand box, there were 5 participants who reported a history of a head and concussion injury and a fracture during competition, and there were 120 participants in the upper left hand box that did not report a history of a head and concussion injury; however, did experience a fracture during competition.

TP= Tendinopathy, PFPS= Patellofemoral Pain Syndrome

Table 3. Significant Association and Likelihood Ratio between injury history and lower extremity joint injury

Injury History	Lower Extremity Joint Injuries During Canada Games Competition			
	Ankle	Hip	Knee	Patellofemoral
Head & Concussion Injuries	$\chi^2 = 0.920$ df = 1 *p* = 0.338 LR = 0.940	$\chi^2 = 0.202$ df = 1 *p* = 0.653 LR = 0.200	$\chi^2 = 0.089$ df = 1 *p* = 0.766 LR = 0.888	$\chi^2 = 0.414$ df = 1 *p* = 0.520 LR = 0.390
Major Surgical Procedure	$\chi^2 = 2.517$ df = 1 *p* = 0.113 LR = 2.614	$\chi^2 = 0.389$ df = 1 *p* = 0.533 LR = 0.377	$\chi^2 = 0.124$ df = 1 *p* = 0.724 LR = 0.124	$\chi^2 = 1.977$ df = 1 *p* = 0.160 LR = 1.748
Neck & Back Injuries	**$\chi^2 = 5.793$** **df = 1** ***p* = 0.016** **LR = 5.509**	$\chi^2 = 0.191$ df = 1 *p* = 0.662 LR = 0.184	**$\chi^2 = 5.595$** **df = 1** ***p* = 0.018** **LR = 6.182**	$\chi^2 = 0.325$ df = 1 *p* = 0.569 LR = 0.362
Trauma or Overuse of Joint & Bone	$\chi^2 = 0.102$ df = 1 *p* = 0.750 LR = 0.102	$\chi^2 = 0.337$ df = 1 *p* = 0.562 LR = 0.337	$\chi^2 = 3.140$ df = 1 *p* = 0.076 LR = 3.140	**$\chi^2 = 8.158$** **df = 1** ***p* = 0.004** **LR = 7.164**
Trauma or Overuse of Ligament & Tendons	$\chi^2 = 2.814$ df = 1 *p* = 0.093 LR = 2.771	**$\chi^2 = 4.410$** **df = 1** ***p* = 0.036** **LR = 4.700**	$\chi^2 = 0.012$ df = 1 *p* = 0.914 LR = 0.012	$\chi^2 = 0.004$ df = 1 *p* = 0.952 LR = 0.004

***Bolded** = Statistically significant difference, LR = Likelihood Ratio

authors have hypothesized the increase in future ankle sprains may be due to the mechanical (persistent ligamentous laxity) and functional (proprioceptive deficits) instability of the joint.[25,50] To the authors' knowledge, this is the first study to report an association between previous major surgical procedures and contusions; however, the potential mechanisms involved in this association is currently unknown. Thereby, further investigation is required to determine the potential mechanism involved.

This current study did not focus on the differences in the association of injury history and lower extremity joint injury between male and female athletes so the authors are unable to ascertain if biological sex may have been a factor in injury risk. Further, self-reported injury history was utilized in this study, and although this is a commonly accepted practice, it results in potential recall bias of athletes underestimating or overestimating their injury history. Previous literature has suggested that athletes neglect reporting symptoms of concussion to medical personnel which means that it is likely that history of concussions may be under reported.[51,52] LaBotz et al[52] reported 48% of collegiate athletes reported signs and symptoms of concussions using the Concussion Symptom Survey Design (CSS), but only 17% reported symptoms of concussions using the Pre-Participation Physical Exam (PPE). It is possible that an underreporting of concussion history during the medial history intake in this study led to the lack of association between concussion history and lower extremity joint injury in the Canada Games athletes included in this study. Internal risk factors, such as an athlete's psychological disposition are poised to modify injury risk.[53,54] Further, Renton et al[55] reported a positive association between athlete identity (eg, depressive symptoms, performance traits, self-worth, motivation) and behaviour (eg, adherence and playing through pain) with injury-related outcomes. Additionally, risk-taking behavior and various psychological factors may be important to consider, especially for athletes who are repeatedly injured.[56] While this current study did not obtain information on athletes' psychological disposition it may be advantageous for researchers to consider these factors in future association studies. While this is the first study to look at the association between self-reported injury history and injury occurrence in athletes participating in the Canada Games competition these findings lack external validity as they cannot be generalized to the general population. Further, due to the de-identified dataset, the authors are not able to ascertain the number of participants who had competed in the Canada Games more than once. Finally, in this study, information regarding injury history was limited to the categorization of previous injuries based on Canada Games medical history intake forms; thus, the criteria that were used for gathering injury history data were non-modifiable. However, this is the only study to specifically assess the association of prior injuries with future injuries incurred in the lower extremity joints, and this is the first study to examine the association between injury history and lower extremity joint injury in the Canada Games.

CONCLUSION

The results of the current study confirm the hypothesis that injury history is associated with lower extremity joint injury across 10 years of Canada Games competitions. Association between history of neck and back injuries with ankle and knee injuries, history of trauma or overuse of ligament or tendon and hip injuries and history of trauma or overuse

Table 4. Significant Association and Likelihood Ratio between injury history and injury type

Injury History	Injury Type During Canada Games Competition						
	Fractures	Sprain	Meniscus	Contusion	TP	Arthritis	PFPS
Head Injuries & Concussion	$\chi^2 = 1.070$ df =1 *p* = 0.301 LR = 1.196	$\chi^2 = 0.975$ df =1 *p* = 0.324 LR = 0.996	$\chi^2 = 0.193$ df =1 *p* = 0.661 LR = 0.182	$\chi^2 = 0.185$ df =1 *p* = 0.667 LR = 0.192	$\chi^2 = 1.095$ df =1 *p* = 0.295 LR = 1.245	$\chi^2 = 0.319$ df =1 *p* = 0.572 LR = 0.289	$\chi^2 = 0.004$ df =1 *p* = 0.953 LR = 0.003
Major Surgical Procedure	$\chi^2 = 0.500$ df =1 *p* = 0.479 LR = 0.537	$\chi^2 = 2.606$ df =1 *p* = 0.106 LR = 2.708	**$\chi^2 = 5.914$** **df =1** ***p* = 0.015** **LR = 4.660**	$\chi^2 = 0.015$ df =1 *p* = 0.902 LR = 0.015	$\chi^2 = 0.977$ df =1 *p* = 0.323 LR = 0.892	$\chi^2 = 0.764$ df =1 *p* = 0.382 LR = 0.948	$\chi^2 = 1.711$ df =1 *p* = 0.191 LR = 1.514
Neck & Back Injuries	$\chi^2 = 0.688$ df =1 *p* = 0.407 LR = 0.796	$\chi^2 = 0.415$ df =1 *p* = 0.520 LR = 0.407	$\chi^2 = 2.031$ df =1 *p* = 0.154 LR = 3.903	$\chi^2 = 0.553$ df =1 *p* = 0.457 LR = 0.504	$\chi^2 = 1.412$ df =1 *p* = 0.235 LR = 1.845	$\chi^2 = 0.000$ df =1 *p* = 0.994 LR = 0.000	$\chi^2 = 0.175$ df =1 *p* = 0.676 LR = 0.190
Trauma or Overuse to Joint & Bone	$\chi^2 = 0.202$ df =1 *p* = 0.653 LR = 0.207	$\chi^2 = 0.045$ df =1 *p* = 0.832 LR = 0.045	$\chi^2 = 2.619$ df =1 *p* = 0.106 LR = 3.010	**$\chi^2 = 4.026$** **df =1** ***p* = 0.045** **LR = 4.493**	**$\chi^2 = 4.053$** **df =1** ***p* = 0.044** **LR = 3.697**	$\chi^2 = 0.021$ df =1 *p* = 0.885 LR = 0.021	**$\chi^2 = 8.158$** **df =1** ***p* = 0.004** **LR = 7.164**
Trauma or Overuse in Ligament & Tendons	$\chi^2 = 0.708$ df =1 *p* = 0.400 LR = 0.739	**$\chi^2 = 4.366$** **df =1** ***p* = 0.037** **LR = 4.287**	$\chi^2 = 0.000$ df =1 *p* = 0.988 LR = 0.000	$\chi^2 = 1.927$ df =1 *p* = 0.165 LR = 2.066	$\chi^2 = 0.582$ df =1 *p* = 0.445 LR = 0.561	$\chi^2 = 0.278$ df =1 *p* = 0.598 LR = 0.265	$\chi^2 = 0.477$ df =1 *p* = 0.490 LR = 0.460

* **Bolded** = Statistically significant difference, TP=Tendinopathy, PFPS=Patellofemoral Pain Syndrome, LR = Likelihood Ratio

of joint or bone and patellofemoral joint injuries were all noted.

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CONFLICT OF INTEREST

The authors have no additional conflicts of interest related to this study to disclose.

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REFERENCES

1. Grandou C, Wallace L, Impellizzeri FM, Allen NG, Coutts AJ. Overtraining in resistance exercise: An exploratory systematic Review and Methodlogical Apprisal of the Literature. *Sports Med*. 2019;50(4):815-828. doi:10.1007/s40279-019-01242-2

2. Saragiotto BT, Di Pierro C, Lopes AD. Risk factors and injury prevention in elite athletes: a descriptive study of the opinions of physical therapists, doctors and trainers. *Braz J Phys Ther*. 2014;18(2):137-143. doi:10.1590/s1413-35552012005000147

3. Kucera KL, Marshall SW, Kirkendall DT, Marchak PL, Garret WE Jr. Injury history as a risk factor for incident injury in youth soccer. *Br J Sports Med*. 2005;39(7):462-466. doi:10.1136/bjsm.2004.013672

4. Steffen K, Myklebust G, Andersen TE, Holme I, Bahr R. Self-reported injury history and lower limb function as risk factors for injuries in female youth soccer. *Am J Sports Med*. 2008;36(4):700-708. doi:10.1177/0363546507311598

5. Orchard JW. Intrinsic and Extrinsic Risk factors for muscle strains in australian football. *Am J Sports Med*. 2001;29(3):300-303. doi:10.1177/03635465010290030801

6. Rauh M, Macera C, Ji M, Wiksten D. Subsequent injury patterns in girls' high school sports. *J Athl Train*. 2006;42:486-494.

7. Walden M, Hagglund M, Ekstrand J. High risk of new knee injury in elite footballers with previous anterior cruciate ligament injury. *Br J Sports Med*. 2006;40(2):158-162. doi:10.1136/bjsm.2005.021055

8. Zazulak BT, Hewett TE, Reeves NP, Goldberg B, Cholewicki J. Deficits in neuromuscular control of the trunk predict knee injury risk: Prospective biomechanical-epidemiologic study. *Am J Sports Med*. 2007;35(7):1123-1130. doi:10.1177/0363546507301585

9. Hagglund M, Walden M, Ekstrand J. Previous injury as a risk factor for injury in elite football: a prospective study over two consecutive seasons. *Br J Sports Med*. 2008;40(9):767-772. doi:10.1136/bjsm.2006.026609

10. Jerosch J, Prymka M. Knee joint proprioception in normal volunteers and patients with anterior cruciate ligament tears, taking special account of the effect of a knee bandage. *Arch Orthop Trauma Surg*. 1996;115(3-4):162-166. doi:10.1007/bf00434546

11. Cooper DJ, Batt ME, O'Hanlon MS, Palmer D. A cross-sectional study of retired great British Olympians (Berlin 1936–Sochi 2014): Olympic career injuries, joint health in later life, and reasons for retirement from Olympic Sport. *Sports Med - Open*. 2021;7(1):54. doi:10.1186/s40798-021-00339-1

12. Nabhan D, Walden T, Street J, Linden H, Moreau B. Sports injury and illness epidemiology during the 2014 Youth Olympic Games: United States Olympic Team Surveillance. *Br J Sports Med*. 2016;50(11):688-693. doi:10.1136/bjsports-2015-095835

13. Garrick JG, Requa RK. The epidemiology of foot and ankle injuries in sports. *Clin Podiatr Med Surg*. 1989;6(3):629-637. doi:10.1016/s0891-8422(23)00176-3

14. Nelson AJ, Collins CL, Yard EE, Comstock DR. Ankle injuries among United States high school sports Athletes, 2005–2006. *J Athl Train*. 2007;42(3):381-387.

15. Anandacoomarasamy A, Barnsley L. Long term outcomes of inversion ankle injuries. *Br J Sports Med*. 2005;39(3):e14. doi:10.1136/bjsm.2004.011676

16. Nicolini AP, De Carvalho RT, Matsuda MM, Sayum Filho J, Cohen M. Common injuries in athletes' knee: experience of a specialized center. *Acta ortop bras*. 2014;22(3):127-131. doi:10.1590/1413-78522014220300475

17. Raines BT, Naclerio E, Sherman SL. Management of anterior cruciate ligament injury: What's in and what's Out? *Ind J Orthop*. 2017;51(5):563-575. doi:10.4103/ortho.ijortho_245_17

18. Levine JW, Kiapour AM, Quatman CE, et al. Clinically relevant injury patterns after an anterior cruciate ligament injury provide insight into injury mechanisms. *Am J Sports Med*. 2013;41(2):385-395. doi:10.1177/0363546512465167

19. Von Porat A, Roos EM, Roos H. High prevalence of osteoarthritis 14 years after an anterior cruciate ligament tear in male soccer players: a study of radiographic and patient relevant outcomes. *Ann Rheum Dis*. 2004;63(3):269-273. doi:10.1136/ard.2003.008136

20. Petersen W, Rembitzki I, Liebau C. Patellofemoral pain in athletes. *Orthop J Sports Med*. 2017;8:143-154. doi:10.2147/oajsm.s133406

21. Rathleff M, Rasmussen S, Olesen J. Unsatisfactory long-term prognosis of conservative treatment of patellofemoral pain syndrome. *Ugeskrift for laeger*. 2012;174:1008-1013.

22. Watson AWS. Ankle sprains in players of the field-games Gaelic football and hurling. *J Sports Med Phys Fit*. 1999;39(1):66-70.

23. Halabchi F, Abolhasani M, Mirshahi M, Alizadeh Z. Patellofemoral pain in athletes: clinical perspectives. *Open Access J Sports Med*. 2017;8:189-203. doi:10.2147/oajsm.s127359

24. Chimera NJ, Merasty D, Lininger MR. Injuries and illness in male and female athletes across 10 years of Canada Games: 614. *Med Sci Sports Exerc*. 2021;53(8S):206-206. doi:10.1249/01.mss.0000761456.26267.9a

25. Murphy DF, Connolly D, Beynnon B. Risk factors for lower extremity injury: a review of the literature. *Br J Sports Med*. 2003;37(1):13-29. doi:10.1136/bjsm.37.1.13

26. Emery CA. Risk factors for injury in child and adolescent sport: a systematic review of the literature. *Clin J Sport Med*. 2003;13(4):256-268. doi:10.1097/00042752-200307000-00011

27. Fulton J, Wright K, Zebrosky B, Zanis M, Drovel C, Butler R. Injury risk is altered by previous injury: A systematic review of the literature and presentation of causative neuromuscular factor. *Int J Sports Phys Ther*. 2014;9(5):583-595.

28. Radebold A, Cholewicki J, Panjabi MM, Patel TC. Muscle response pattern to sudden trunk loading in healthy individuals and in patients with chronic low back pain. *Spine*. 2000;25(8):947-954. doi:10.1097/00007632-200004150-00009

29. Radebold A, Cholewicki J, Polzhofer GK, Greene HS. Impaired postural control of the lumbar spine is associated with delayed muscle response times in patients with chronic idiopathic low back pain. *Spine*. 2001;26(7):724-730. doi:10.1097/00007632-200104010-00004

30. Reeves NP, Cholewicki J, Milner TE. Muscle reflex classification of low-back pain. *J Electromyog Kinesiol*. 2005;15(1):53-60. doi:10.1016/j.jelekin.2004.07.001

31. Vad VB, Bhat AL, Basrai D, Gebeh A, Aspergren DD, Andrews JR. Low back pain in professional golfers: the role of associated hip and low back range-of-motion deficits. *Am J Sports Med*. 2004;32(2):494-497. doi:10.1177/0363546503261729

32. Müller R, Ertelt T, Blickhan R. Low back pain affects trunk as well as lower limb movements during walking and running. *J Biomech*. 2015;48(6):1009-1014. doi:10.1016/j.jbiomech.2015.01.042

33. Vad VB, Gebeh A, Dines D, Altchek D, Norris B. Hip and shoulder internal rotation range of motion deficits in professional tennis players. *J Sci Med Sport*. 2003;6(1):71-75. doi:10.1016/s1440-2440(03)80010-5

34. Barbee Ellison J, Rose SJ, Sahrmann SA. Patterns of hip rotation range of motion: A comparison between healthy subjects and patients with low back pain. *Phys Ther*. 1990;70(9):537-541. doi:10.1093/ptj/70.9.537

35. Willy RW, Scholz JP, Davis IS. Mirror gait retraining for the treatment of patellofemoral pain in female runners. *Clin Biomech*. 2012;27(10):1045-1051. doi:10.1016/j.clinbiomech.2012.07.011

36. Willson JD, Ratcliff OM, Meardon SA, Willy RW. Influence of step length and landing pattern on patellofemoral joint kinetics during running. *Scand J Med Sci Sports*. 2015;25(6):736-743. doi:10.1111/sms.12383

37. Collado H, Fredericson M. Patellofemoral pain syndrome. *Clin Sports Med*. 2010;29(3):379-398. doi:10.1016/j.csm.2010.03.012

38. Boling MC, Padua DA, Marshall SW, Guskiewicz K, Pyne S, Beutler A. A prospective investigation of biomechanical risk factors for patellofemoral pain syndrome the joint undertaking to monitor and prevent ACL injury (JUMP-ACL) Cohort. *Am J Sports Med*. 2009;37(11):2108-2116. doi:10.1177/0363546509337934

39. Kucera KL, Marshall SW, Wolf SH, Padua DA, Beutler AI. Association of injury history and incident injury in cadet basic military training. *Med Sci Sports Exerc*. 2016;48(6):1053-1061. doi:10.1249/mss.0000000000000872

40. Driban JB, Lo GH, Eaton CB, Price LL, Lu B, McAlindon TE. Knee pain and a prior injury are associated with increased risk of a new knee injury: Data from the Osteoarthritis Initiative. *J Rheumatol*. 2015;42(8):1463-1469. doi:10.3899/jrheum.150016

41. Manske RC, Davies GJ. Examination of the patellofemoral joint. *Int J Sports Phys Ther*. 2016;11(6):831-853.

42. Dixit S, DiFiori JP, Burton M. Management of patellofemoral pain syndrome. *J Am Family Physician*. 2015;75(2):194-202.

43. Desai SN, Grierson R, Manoli A II. The Cavus Foot in Athletes: Fundamentals of examination and treatment. *Op Techn Sports Med*. 2010;18(1):27-33. doi:10.1053/j.otsm.2009.10.002

44. Friel K, Mclean N, Myers C, Caceres M. Ipsilateral hip abductor weakness after inversion ankle sprain. *J Athl Train*. 2006;41(1):74-78.

45. Gilmer G, Washington J, Oliver G. Assessment of lumbopelvic–hip complex instability and segmental sequencing amongst softball athletes. *Int Biomech*. 2018;5(1):36-45. doi:10.1080/23335432.2018.1481456

46. Ekstrand J, Gillquist J. Soccer injuries and their mechanisms a prospective study. *Med Sci Sports Exerc*. 1983;15(3):267. doi:10.1249/00005768-198315030-00014

47. Arnason A, Sigurdsson SB, Gudmundsson A, Holme I, Engebretsen L, Bahr R. Risk factors for injuries in football. *Am J Sports Med*. 2004;32(1):5-16. doi:10.1177/0363546503258912

48. Ekstrand J, Gillquist J. The avoidability of soccer injuries. *Int J Sports Med*. 1983;4(2):124-128. doi:10.1055/s-2008-1026025

49. Bahr R, Bahr IA. Incidence of acute volleyball injuries: a prospective cohort study of injury mechanisms and risk factors. *Scand J Med Sci Sports*. 1997;7(3):166-171. doi:10.1111/j.1600-0838.1997.tb00134.x

50. Dvorak J, Junge A. Football injuries and physical symptoms. A review of the literature. *Am J Sports Med*. 2000;28(5_suppl):3-9. doi:10.1177/28.suppl_5.s-3

51. McCrea M, Hammeke T, Olsen G, Leo P, Guskiewicz K. Unreported concussion in high school football players: Implications for prevention. *Clin J Sport Med*. 2004;14(1):13-17. doi:10.1097/00042752-200401000-00003

52. LaBotz M, Martin MR, Kimura IF, Hetzler RK, Nichols AW. A comparison of a peparticipation evaluation history form and a symptom-based concussion survey in the identification of previous head injury in collegiate athletes. *Clin J Sport Med*. 2005;15(2):73-78. doi:10.1097/01.jsm.0000157649.99867.fc

53. Wiese-Bjornstal DM. Sport Injury and College Athlete health across the lifespan. *J Intercoll Sport*. 2009;2(1):64-80. doi:10.1123/jis.2.1.64

54. Williams JM, Andersen MB. Psychosocial antecedents of sport injury: Review and critique of the stress and injury model'. *J Appl Sport Psych*. 1998;10(1):5-25. doi:10.1080/10413209808406375

55. Renton T, Petersen B, Kennedy S. Investigating correlates of athletic identity and sport-related injury outcomes: a scoping review. *BMJ Open*. 2021;11(4):e044199. doi:10.1136/bmjopen-2020-044199

56. Johnson U, Ekengren J, Andersen MB. Injury Prevention in Sweden: Helping soccer players at risk. *J Sport Exerc Psychol*. 2005;27(1):32-38. doi:10.1123/jsep.27.1.32