THE NEW ARMENIAN MEDICAL JOURNAL
Vol.15 (2021), No 4, p.70-76

CAUSATION AND PATTERN OF KNEE INJURIES IN SAUDI MILITARY PERSONNEL - A MULTICENTER RETROSPECTIVE ANALYSIS

Albishri S.F.[1], Ahmad R.[2], Al Zahrani E.M.[1], Waheed K.B.[3], Jebakumar A.Z.[4], Woodman A.[4*]

[1] Department of Physical Therapy, Prince Sultan Military College of Health Sciences, Dhahran, Saudi Arabia
[2] Department of Physical Therapy, College of Applied Medical Sciences, Imam Abdulrahman Bin Faisal University, Saudi Arabia
[3] Radiodiagnostic & Imaging Department, King Fahad Military Medical Complex, Dhahran, Saudi Arabia
[4] Vice Deanship of Postgraduate Studies and Research, Prince Sultan Military College of Health Sciences, Dhahran, Saudi Arabia

Received 08.09.2020; accepted for printing 07.08.2021

Abstract

Knee injuries are a major health concern for military personnel seeking to return to active-duty. Nevertheless, there is a lack of research about the incidence and causative factors associated with knee injuries among active-duty military personnel in Saudi Arabia. This retrospective cohort research aimed to start group studies on the incidence of knee injuries among active military personnel in Saudi Arabia.

The objective of the study was to evaluate the causative factors associated with this injury and pattern of its involvement. This study included data of 2230 patients aged 18 to 60 years with knee injuries, with mean age of 42.73 SD ±16.343. Data was collected from nine of the Saudi military hospitals in a period of six years (2010-2016) and analyzed using descriptive statistics and regression models.

The frequency distribution showed that cruciate ligaments (ACL and PCL) were the most commonly affected structures in knee injuries (45.2%), followed by menisci (24.9%) and internal derangement (10.1%) with incidence rate 4.57, 0.25, and 0.10, respectively. Sports and military exercise-related injuries were found to be the most significant causative factors involved in all knee injuries (30.5%), followed by non-military accidental injuries at 25% (p = 0.000).

This study found that cruciate ligament injuries followed by meniscus injuries were the most common knee injuries among Saudi active-duty personnel. Sports and military exercises were found most common causes for knee injuries. Injuries negatively impacted productivity and military training as these prevent military personnel from being ready for military service due to treatment and recovery.

More research is needed on time spent in rehabilitation away from active service as a result of the cruciate ligament injuries that need time to return to daily activities.

Keywords: *Anterior cruciate ligament, knee injuries, military personnel, Saudi Arabia*

Introduction

Knee injuries and associated risk factors are a major health concern for military personnel seeking to return to active-duty. Knee injuries can result from direct training, deployment, or other military operations [*Hsiao M et al., 2010; Boling M et al., 2010; Cameron K, Owens B, 2014*]. The consequences of knee injuries are the lost duty days, medical costs of treatment, and the impact that injury can have on a person's quality of life. Knee injuries among military personnel interrupt military service and reduce the overall combat capability of the army. In addition to the adverse effect of knee injuries on health, the incidence of these injuries cannot be predicted and prevented

Address for Correspondence:
Alexander Woodman, Ph.D., M.Sci., M.P.H.
Prince Sultan Military College of Health Sciences
Vice Deanship of Postgraduate Studies and Research
Scientific Research Unit
Al Amal Dhahran 34313, Saudi Arabia
Tel.: +1 310 498 4385
E-mail: alexwoodman.ucla@gmail.com

[*Cameron K, Owens B, 2014; Teyhen D et al., 2015*]. Therefore, it is important to understand the types or patterns of knee injuries and the causative factors responsible for these injuries. This will help to develop strategies to reduce injury incidence and provide resources for rehabilitation and return to active service [*Kuikka P et al., 2013; Teyhen D et al., 2015*].

Knee injuries range from ligament injuries to cartilage, tendon, and bone injuries. The most common types of knee injuries are the anterior cruciate ligament (ACL), medial meniscus tear, the chondral lesion, medial collateral ligament tear, contusion damage arising from trauma, lateral meniscus tear, and patellar dislocation. Additional evidence in the literature indicates that males under the age of 30 are more likely to experience knee injuries and males under the age of 20 had a higher chance of developing a patellar dislocation than people aged 40 years and older [*Kuikka P et al., 2013; Abt J et al., 2014*].

Various factors influence the relatively high incidence of ACL injuries compared to a posterior cruciate ligament (PCL), lateral collateral ligament (LCL), and medial collateral ligament (MCL) among active-duty military service personnel [*Kuikka P et al., 2009; Kang S et al., 2016*]. Thus, in addition to the anatomy of the knee joint, neuromuscular factors are also significant predictors of ACL injuries. Further, the anatomical risk factors relating to ACL injuries include a smaller femoral intercondylar notch width, increased slope of the tibial plateaus, and increased anterior-posterior knee laxity as well as the relevance of quadriceps to hamstring strength ratio (i.e., a ratio of 0.8 or 80% muscle activity is required as opposed to ratio of 0.5 or 50% hamstring strength to quadriceps that is sufficient for daily routine activities) as a possible predictor of ACL tears [*Smith H et al., 2012; Rubinstein A, Postma W, 2015*]. Several neuromuscular risk factors include knee extension during deceleration, lateral trunk movements, and rear weight distribution, further intensifying anatomical risk factors. These factors are especially important since they are quite common in sports and physical exercise and are usually performed by military personnel on active-duty [*Andersen K et al., 2016*]. In addition to the risk factors mentioned above, there is a significant association between the risk of knee injury and body mass index (BMI). Incidence of knee injuries such as osteoarthritis (ageing, wear and tear), meniscal and ligament abnormalities (intrasubstance degeneration, tears) increases with the high BMI [*Weidow J, 2006; Scott S et al., 2015*].

Several studies have been conducted among the Saudi population to assess knee injuries and related risk factors [*Althunyan A et al., 2017; Alrubayyi M et al., 2018 Almaawi A et al., 2020*]. Althunyan and co-authors (2017) reported that knee injuries are a common health problem for active cyclists in the Eastern Province of Saudi Arabia. A cross-sectional study by Almaawi et al. (2020) reported an overall prevalence of knee injuries (23.2%) among male students at King Saud University, with ACL being among the most common. The majority were injured during sports, especially in football, and 68.7% participated in the non-contact mechanism of injuries. An earlier study by Alrubayyi et al. (2018) among the residents of Mecca reported that ACL is a prevalent injury, with sports being the most significant risk factor.

Although there have been studies about knee injuries among the general public in Saudi Arabia, to the best of the authors' knowledge, none have been conducted to assess the incidence of knee injuries specifically among the Saudi military population. Thus, the emphasis should be on conducting research on knee injuries and implementing preventive strategies to minimize risk factors while serving in the military. Therefore, the current retrospective cross-sectional research aimed to start group studies on the incidence of knee injuries among active military personnel presented to various military hospitals in Saudi Arabia. The objective of the study was to evaluate the pattern of knee injuries and potential causative factors associated with such injuries.

To overcome it is possible, due to the uniting the knowledge and will of all doctors in the world

Material and Methods

This retrospective cohort re-

search was aimed to assess the incidence, pattern and causative factors associated with knee injuries among military personnel on active-duty at four military branches in Saudi Arabia: land forces, air forces, naval forces, and air defense forces. The study was conducted between 2010 and 2016. The data collection process began with specific approvals from the relevant medical authorities. The Principal Investigator has received appropriate ethics and safety approvals.

The data collection process involved extracting data from the available medical records of military hospitals. Nine of the thirteen military hospitals agreed to collaborate on this study: King Fahad Military Medical City (KFMMC, Dhahran); Khamis Mushait Military Hospital; Jubail Military Hospital; Jeddah Military Hospital; Hafr Albatin Military Hospital; Sharourah Military Hospital; Prince Sultan Military Medical City (Riyadh); Dhahran Airbase Military Hospital; Alhada Military Hospital (Taif). A total of n = 2230 patients with knee injuries were included in the study.

The list of variables included age, diagnosis or pattern, and cause of injury. In addition, hospital admissions' data were summarized by major diagnostic categories at a seven-digit level using the International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM) to record each patient's experience in military hospitals and outpatient visits. The International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM) is an updated version of the ICD and is expected to become the new standard for healthcare facilities. The use of ICD-10-CM subclasses makes it possible to develop more than 70,000 new codes. The system uses alphanumeric codes to identify diseases and related problems accurately. Therefore, the ICD-10-CM classification was instrumental in this research in facilitating the extraction of relevant data [*Centers for Disease Control and Prevention (CDC), 2020*].

Diagnoses of knee injuries were based on findings of plain film radiographs and cross-sectional studies (computed tomography or magnetic resonance imaging) in patients who presented in hospitals through outpatient departments and emergencies, got admitted, operated or discharged. Pattern of knee injuries was defined by an affected structure within a knee complex (i.e. an isolated abnormality). In cases of combined injuries, structure with most profound abnormality was documented for diagnosis. An experienced radiologist categorized knee injuries into bony (femoral, tibial, fibular), ligament (anterior and posterior cruciate, medial and lateral collateral), cartilage (femoral, tibial), meniscal (medial, lateral), malalignment or mechanical instability (congenital tibia vara, genu valgum), external (skin, wound) and synovial (inflammation or infection). Causes of knee injuries were grouped under sports and (military) exercise-

Table 1.

Descriptive characteristics of the sample (n = 2230).

Characteristics		Frequency (n)	Percentage (%)
Age (years)	< 30	721	32.3
	31 – 40	513	23.0
	41 – 50	144	6.5
	51 – 60	852	38.2
		Mean	***SD***
		42.73	*16.343*
Diagnosis	Ligament Injury	1018	45.7
	Bony Injury	110	4.9
	Cartilage Injury	200	9.0
	Mechanical instability	245	11.0
	Meniscal Injury	588	26.4
	External or open wound injury	33	1.5
	Synovial injury	36	1.6
Cause of Injury	Non-military accidental	752	33.7
	Sports and Military exercise	991	44.4
	Road Traffic Accident	276	12.4
	Undetermined	211	9.5
Hospital	Hafr Albatin	80	3.6
	KFMMC	191	8.6
	Jubail	99	4.4
	Airbase	362	16.2
	Shoruruh	16	0.7
	Jeddah	34	1.5
	Taif	176	7.9
	Khamis Mushait	126	5.7
	Riyadh	1146	51.4

Table 2.

Association between diagnosis and cause of injury (n = 2230).

Diagnoses	Causes of Knee Injuries				Total n (%)
	Non-military n (%)	Military exercise/ Sports Injury n (%)	RTA n (%)	Undetermined n (%)	
Ligament Injury	227 (22.3%)	595 (58.4%)	165 (16.2%)	31(3.0%)	1018 (100.0%)
Bony Injury	4 (3.6%)	23 (20.9%)	80 (72.7%)	3(2.7%)	110 (100.0%)
Cartilage Injury	88 (44.0%)	46 (23.0%)	0(0.0%)	66 (33.0%)	200 (100.0%)
Mechanical instability	102 (41.6%)	121 (49.4%)	13(5.3%)	9(3.7%)	245 (100.0%)
Meniscal Injury	313 (53.2%)	183 (31.1%)	12(2.0%)	80 (13.6%)	588 (100.0%)
Open wound	2 (6.1%)	23 (69.7%)	6 (18.2%)	2(6.1%)	33 (100.0%)
Synovial injury	16 (44.4%)	0 (0.0%)	0(0.0%)	20 (55.6%)	36 (100.0%)
Total	752 (33.7%)	991 (44.4%)	276 (12.4%)	211(9.5%)	2230 (100.0%)

Notes: * Significant at 95% since *P*-value < 0.05

related, non-military accidental injuries (sprains or twisting injuries), road traffic accident (RTA) and those undetermined (i.e., those not explained by any trauma or accident).

The main factors during this study were incidence of knee injuries per year and causative factors. The incidence rate was calculated by dividing the total number of incidences of a specific knee injury by the total number of knee case. The correlation between the incidence of knee injuries and various causative factors was assessed using a multivariate regression model. This model was applied to estimate the number of knee injuries per 100 person-years depending on age, cause of injury, and military unit. SPSS software version 23.0 (SPSS Inc., Illinois, USA) was used for statistical analysis. The association between diagnosis and injury cause was assessed using the Chi-square test.

Results

This retrospective cross-sectional research extracted data on the incidence of knee injuries in nine military hospitals over six years (2010-2016). Total data of n = 2230 patients with a mean age of 42.73 years ± 16.343 SD was extracted (Table 1). The frequency distribution showed that ligament injury was the most common of knee injuries (45.7%), followed by meniscal injury (26.4%) and malalignment or mechanical instability (11.9%).

Although the overall results of the current study indicated that ACL/PCL and meniscus injuries were the most common diagnoses, contradictory results were obtained in some study sites (hospitals). Thus, data from the Sharourah Military hospital n = 16 (0.7%), Jeddah Military hospital n = 34 (1.5%) and Alhada Military Hospital (Taif) n = 176 (7.9%) showed that the most frequent knee injuries were due to RTA unknown to the other two hospitals (Table 1).

Sports and related activities (44.4%) accounted for most causes of knee injuries among military personnel, taking into account the diagnosis and cause of injuries in a cross-tabulation (Table 2). Sports activities were a significant risk factor for the development of ACL/PCL (p = 0.000), bony injury (p = 0.000), and meniscus injuries (p = 0.000). Twisting injury (33.7%) was the second most significant knee injury factor in this sample.

The results of the present study indicated that age was not a significant risk factor for the development of two common ACL/ PCL and meniscus injuries (Table 3).

Discussion

This retrospective cohort research aimed to start group studies on the incidence of knee injuries among active military personnel (all hospitalized/ in-patient and discharged/ outpatient) in Saudi Arabia. The objectives of the study were to evaluate patterns of knee injuries and the potential causative factors associated with such injuries. The study was conducted between 2010 and 2016.

The data collection process involved extracting

Table 3.

Association between age group and cause of injury (n = 2230).

Age group	Causes of Knee Injuries				Total
	Non-military accidental	Military exercise/ Sports	RTA	Undetermined	
< 30	207 (28.7%)	317 (44.0%)	93 (12.9%)	104 (14.4%)	721 (100.0%)
31 - 40	156 (30.4%)	225 (43.9%)	71 (13.8%)	61 (11.9%)	513 (100.0%)
41 - 50	49 (34.0%)	53 (36.8%)	14(9.7%)	28 (19.4%)	144 (100.0%)
51 - 60	340 (39.9%)	396 (46.5%)	98 (11.5%)	18(2.1%)	852 (100.0%)
Total	752 (33.7%)	991 (44.4%)	276 (12.4%)	211(9.5%)	2230 (100.0%)

*Notes: *Significant at 95% since P-value < 0.05.*

data from the available medical records of military hospitals. Nine of the thirteen military hospitals agreed to collaborate on this study: King Fahad Military Medical City (KFMMC, Dhahran); Khamis Mushait Military Hospital; Jubail Military Hospital; Jeddha Military Hospital; Hafr Albatin Military Hospital; Sharourah Military Hospital; Prince Sultan Military Medical City (Riyadh); Dhahran Airbase Military Hospital; Alhada Military Hospital (Taif).

The frequency distribution showed that ACL/PCL was the most common of knee injuries, followed by meniscus injury and malalignment or incongruency. These findings are consistent with several previously published studies on knee injuries [*Rezasoltani Z et al., 2016; Barrow A et al., 2017*]. Thus, Rezasoltani Z and co-authors (2016) conducted a similar study among Iranian armed forces and reported that ACL injuries were the most common knee injuries, followed by meniscus injuries. However, Kuikka P and co-authors (2013), in their retrospective study among young male military personnel, reported that patellar dislocation was the most common type of knee disorder with an incidence rate of 3.1 per 1000 person-years, followed by meniscal injuries (2.2 cases per 1000 person-years).

The physical training program was practically the same for the entire sample, since all officers and soldiers graduated from the same military school and the same military institutes, where there is not much difference in the physical training program. All fractures were caused by military or sports injuries, which is also a common factor among militants.

Sports and military exercise-related activities (44.4%) accounted for most causes of knee injuries among military personnel, including the development of ACL/PCL, bony injury, and meniscus injuries. Non-military accidental injury was the second most significant knee injury. These results were similar to those by Hauret K and co-authors (2015), who reported that 52% of the causes of injuries among military personnel were physical exercise and sports-related activities (i.e., sports in the field). The present study results indicated that age was not a significant risk factor for the development of the two common knee injuries ACL/PCL and meniscus injuries. In comparison, the findings by Jones J and co-authors (2012), Pihlajamäki H and co-authors (2017), Kuikka P and co-authors (2013), and Gordon B and co-authors (2013) found age as a significant risk factor for knee injuries.

In sum, this study revealed that ACL/PCL injuries followed by meniscus injuries were the most common knee injuries among active-duty military personnel in Saudi Arabia. Sports activities were commonly cited as the causative factors contributing towards knee injuries. The injuries negatively influence operational productivity and military training by preventing military readiness due to time spent out of service during treatment and rehabilitation.

Additional research is required on the data pertaining to time spent in rehabilitation, away from the active-duty resulting from ACL/PCL injuries, since any patient with ACL/PCL needs time to return to daily activities. Although Saudi military hospitals have proper and qualified rehabilitation methods under the guidance of qualified physiotherapists, in most cases, patients do not adhere to the processes and treatment plan. Future research

is required to develop effective interventions to reduce the impact of preventable risk factors such as sports and related exercise that contribute to the development of knee injuries since the sports category is broad and not very specific. Thus, this study can be viewed as hypothesis-generating research that supports future research efforts that will redirect to possible alternative factors leading to knee injuries, specifically ACL/PCL injuries.

Limitations

Current research should be recognized within specific limitations. Data was collected from only nine of the thirteen military hospitals. The remaining four did not have enough capacity to accommodate the ICD-10-CM coding system. The ICD-10-CM coding for knee injuries was not the same in all hospitals. Results were not compared amongst the 4 military branches. Risk factors (like obesity or increased BMI) and mechanism of injuries (like twisting or translational force) were not compared with pattern and type of injuries.

One risk factor to be investigated in future studies is whether service in a particular military unit may affect the incidence of knee injuries. Only three hospitals out of nine consider the type of military unit when coding for different types of knee injuries, which was another limitation for more ac-

REFERENCES

1. *Abt JP, Sell TC, Lovalekar MT, Keenan KA, Bozich AJ., et al,* (2014). Injury epidemiology of US Army special operations forces. Military medicine. 179(10): 1106-1112.
2. *Almaawi A, Awwad W, Bamugaddam A, Alasheikh M, Muaddi M., et al,* (2020). Prevalence of knee injuries among male college students in Riyadh, Kingdom of Saudi Arabia. Journal of orthopaedic surgery and research. 15(1): 1-8.
3. *Alrubayyi M, Alzahrani S, Alotaibi A, Albalawi A, Asiri M., et al,* (2018). A survey of injuries to the anterior cruciate ligament among Makkah population, saudi arabia: prevalence and observations on injury mechanism. Int J Adv Res. 6 :814-819.
4. *Althunyan AK, Darwish MA, Abdel Wahab MM,* (2017). Knee problems and its associated factors among active cyclists in Eastern Province, Saudi Arabia. J Family Community Med. 24(1): 23-29.
5. *Andersen KA, Grimshaw PN, Kelso RM, Bentley DJ,* (2016). Musculoskeletal Lower Limb Injury Risk in Army Populations. Sports Med Open. 2: 22.
6. *Barrow AE, Sheean AJ, Burns TC,* (2017). Return to duty following combat-related multi-ligamentous knee injury. Injury.48(4): 861-865.
7. *Boling M, Padua D, Marshall S, Guskiewicz K, Pyne S, Beutler A,* (2010). Gender differences in the incidence and prevalence of patellofemoral pain syndrome. Scand J Med Sci Sports. 20(5): 725-730.
8. *Cameron KL, Owens BD,* (2014). The burden and management of sports-related musculoskeletal injuries and conditions within the US military. Clin Sports Med. 33(4): 573-589.
9. *Centers for Disease Control and Prevention* (2020). International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM). Available from: https://www.cdc.gov/nchs/icd/icd10cm.htm
10. *Gordon B, Moshe S, Blanc PD, Derazne E, Tzur D., et al,* (2013). The association between occupation and the incidence of knee disorders in young military recruits. Military medicine. 178(1): 61-67.
11. *Hauret KG, Bedno S, Loringer K, Kao TC, Mallon T., et al,* (2015). Epidemiology of Exercise- and Sports-Related Injuries in a Population of Young, Physically Active Adults: A Survey of Military Servicemembers. Am J Sports Med. 3(11): 2645-2653.
12. *Hsiao M, Owens BD, Burks R, Sturdivant RX, Cameron KL,* (2010). Incidence of acute traumatic patellar dislocation among active-duty United States military service members. Am J Sports Med.38(10): 1997-2004.
13. *Jones JC, Burks R, Owens BD, Sturdivant RX, Svoboda SJ., et al,* (2012). Incidence and risk factors associated with meniscal injuries among active-duty US military service members. J Athl Train. 47(1): 67-73.

14. *Kang S, Park J, Kang SB, Chang CB,* (2016). MRI findings of young male soldiers with atraumatic anterior knee pain. Scand J Med Sci Sports. 26(5): 572-578.

15. *Kuikka PI, Pihlajamäki HK, Mattila VM,* (2013). Knee injuries related to sports in young adult males during military service - incidence and risk factors. Scand J Med Sci Sports. 23(3): 281-287.

16. *Kuikka PI, Sillanpää P, Mattila VM, Niva MH, Pihlajamäki HK,* (2009). Magnetic resonance imaging in acute traumatic and chronic meniscal tears of the knee: a diagnostic accuracy study in young adults. Am J Sports Med. 37(5): 1003-1008.

17. *Pihlajamäki HK, Parviainen MC, Kautiainen H, Kiviranta I,* (2017). Incidence and risk factors of exercise-related knee disorders in young adult men. BMC Musculoskelet Disord. 18(1): 340.

18. *Rezasoltani Z, Dehghan F, Azizan A, Dadarkhah A, Yadegarian F,* (2016). The Frequency of Knee-Joint Injuries Caused by Sports Activities Among the Armed Forces Personnel. J Arch Mil Med. 4(4): e38447

19. *Rubinstein A, Postma W,* (2015). Anterior Cruciate Ligament Injury Current Understanding of Risk Factors. Orthopedics and Rheumatology Open Access J. 1(3): 60-68.

20. *Scott SA, Simon JE, Van Der Pol B, Docherty CL,* (2015). Risk Factors for Sustaining a Lower Extremity Injury in an Army Reserve Officer Training Corps Cadet Population. Mil Med. 180(8): 910-916.

21. *Smith HC, Vacek P, Johnson RJ, Slauterbeck JR, Hashemi J., et al*, (2012). Risk factors for anterior cruciate ligament injury: a review of the literature—part 1: neuromuscular and anatomic risk. Sports Health. 4(1): 69-78.

22. *Teyhen DS, Shaffer SW, Butler RJ, Goffar SL, Kiesel KB., et al*, (2015). What risk factors are associated with musculoskeletal injury in US Army Rangers? A prospective prognostic study. Clinical Orthopaedics and Related Research®. 473(9): 2948-2958.

23. *Weidow J,* (2006). Lateral osteoarthritis of the knee. Etiology based on morphological, anatomical, kinematic and kinetic observations. Acta Orthop Suppl. 77(322): 3-44.

THE NEW ARMENIAN MEDICAL JOURNAL
Vol.15 (2021). No 4

CONTENTS

The Journal is founded by
Yerevan State Medical
University after M. Heratsi.

Address for correspondence:

Yerevan State Medical University
2 Koryun Street, Yerevan 0025,
Republic of Armenia

Phones:

(+37410) 582532 YSMU
(+37410) 580840 Editor-in-Chief
Fax: (+37410) 582532
E-mail: namj.ysmu@gmail.com, ysmiu@mail.ru
URL: http//www.ysmu.am

Our journal is registered in the databases of Scopus, EBSCO and Thomson Reuters (in the registration process)

SCOPUS EBSCO THOMSON REUTERS

Copy editor: Tatevik R. Movsisyan

Printed in "collage" LTD
Director: A. Muradyan
Armenia, 0002, Yerevan,
Saryan St., 4 Building, Area 2
Phone: (+374 10) 52 02 17,
E-mail: collageltd@gmail.com

OFFICIAL PUBLICATION OF THE YEREVAN STATE MEDICAL UNIVERSITY