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# Lack of Correlation between Anterior Cruciate Ligament Injury Risk Factors and Its Severity Degree

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**Abstract:** Anterior Cruciate Ligament (ACL) injury is a prevalent, severe, and costly orthopedic condition affecting individuals. The ACL prevalence is related to harder activity. This study aims to explore the correlation between age, Body Mass Index (BMI), and occupational history with the severity of ACL injuries at Gatot Soebroto Central Army Hospital. The analysis adopted a cross-sectional design and chi-square test, examining 121 medical records from 2 groups of patients that were civilians and National Armed Forces (TNI). There are 88.4% of 19 – 44 years; 50.4% with normal body mass index (BMI), and 49.6% overweight/obese; 49.6% civilian and 50.4% TNI; 70.2% with total tear, and the rest was partial tear of participants. The data analysis indicated p-values of 0.633 for age, 0.953 for BMI, and 0.126 for occupational history concerning their association with the severity of ACL injuries. Additionally, all of variables showed Odds Ratio (OR) values > 1 (OR 1.608 for Age, OR 1.024 for BMI, and OR 1.853 for occupational history), means that there was no significant correlation between variables and the severity of ACL injuries. Despite the lack of significant correlation, these risk factors may still increased susceptibility to severe ACL injuries.

**Keywords:** ACL; risk factors; severity degree; chi-squares

## INTRODUCTION

Injury is a state where an individual engages in an activity beyond their physical capacity or a condition that arises due to an imbalance between the stress from the activity undertaken and their physical abilities. Based on the 2018 Basic Health Research (Riskesdas) data, injuries to the lower limbs hold the top position in illustrating the proportion of body parts damaged due to injuries, accounting for 67.9%. Among all injuries to the lower extremities, particularly the knee, the Anterior Cruciate Ligament (ACL) is the most frequently affected, constituting around 50% of all knee ligament injuries.[1] The ACL injury stands out as one of the most frequently encountered orthopedic injuries in hospitals. The tearing of this ligament is both common and severe, involving substantial costs and potential career implications for athletes. The ACL injuries often necessitate surgical intervention and long-term rehabilitation for reconstruction. Moreover, many patients grapple with substantial disabilities post-ACL injury. This kind of injury can bring about changes in knee mechanics, leading to an elevated risk of meniscal injuries and the onset of osteoarthritis.[2]

The ACL injuries are a common occurrence annually, with an estimated count surpassing 200,000 injuries and over 100,000 ACL reconstructions carried out each year in the United States.[3] The incidence of ACL injuries is elevated in individuals participating in physically demanding activities associated with high-risk sports such as basketball, soccer, skiing, and football. The prevalence of injuries is higher in females compared to males, ranging from 2.4% to 9.7%.[3] A recent study on the incidence of ACL injuries in Indonesia

reveals that knee injuries rank second after back pain in the country, with an occurrence rate of 48 per 1000 patients, and 9% of these cases involve ACL injuries.[4]

Numerous factors can elevate the probability of ACL injury. These risk factors can be divided into two primary categories: external risk factors (arising from the environment) and internal risk factors (arising from within oneself). Furthermore, these factors can be classified as modifiable (body mass index/BMI, activity, and footwear usage) or non-modifiable (age, gender, ligament size), emphasizing the importance of understanding them to prevent potential injuries.[5] Age and BMI are critical intrinsic factors influencing ACL injuries. The ACL structural and functional capacities decrease with age, notably in patients aged 67-90 compared to younger age groups. Ligament cell levels also show increased tissue degeneration with age.[6] Excess weight and obesity elevate mechanical stress on lower limb joints, causing abnormal loading, cartilage imbalance, and morphological changes, specifically damaging the medial articular cartilage.[7]

The ACL injuries can occur in anyone, especially those engaged in high-intensity or overuse activities with inadequate focus on their movements.[4] National Armed Forces (TNI), with their heavy physical duties defending Indonesia, face a heightened risk of ACL injuries and musculoskeletal disorders.[8] High daily activity increases the risk of ACL injuries compared to low daily activity levels.[9] However, to date, there is no data available that explains or provides an overview of the prevalence of ACL injuries among the TNI members.

Proactive measures are needed to address injury mechanisms and mitigate internal and external risk factors, reducing the overall risk of injury complications.[10] This is crucial, especially considering the socio-economic impact of severe ACL injuries. Higher injury severity correlates with increased treatment costs, prolonged healing time, and a diminished likelihood of the patient returning to their pre-injury condition. These risk factors, such as age, body mass index (BMI), and occupational history, are significant contributors that warrant special attention to decrease the incidence of ACL injuries in the community.[5,11,12] Based on this information, the researcher aims to conduct further studies on the correlation between age, BMI, and occupational history (Civilian and National Armed Forces) with the severity of ACL injuries at Gatot Soebroto Central Army Hospital (RSPAD Gatot Soebroto).

**MATERIAL AND METHOD**

This research employed a quantitative analysis method with a cross-sectional design. The study population comprised all patients diagnosed with ACL injuries at RSPAD Gatot Soebroto, Central Jakarta, from January 2021 to December 2022, with a total sample size of 121 individuals. Sampling was conducted using a consecutive sampling method, where medical record data were collected from all samples meeting the inclusion criteria during a specified timeframe (from January 2021 – December 2022) until the required sample size was attained.[13] The inclusion criteria for this study include patients clinically diagnosed with ACL injuries, those with complete data on anthropometry, age, and employment status, and patients treated between January 2021 and December 2022 at Gatot Soebroto Army Central Hospital, Central Jakarta. The exclusion criteria are patients with ACL injuries resulting from prior knee surgeries, those without MRI-based severity data for their ACL injuries, and patients with a history of previous ACL injuries.

The data collected comprised secondary information from patient medical records at RSPAD Gatot Soebroto, spanning from January 2021 to December 2022. The gathered details encompassed patient identities, age, body weight, occupational history, and Magnetic Resonance Imaging (MRI) interpretation data. The patient's age, BMI, and employment history data were extracted from their medical records.

The age was categorized into four groups based on the classifications established by the Ministry of Health of the Republic of Indonesia in 2016, while BMI was classified into three groups according to the categories provided by the Ministry of Health in 2014. Employment history was divided into two major categories for the patients included TNI and civilians. The MRI examination data were utilized in this study as MRI is the most commonly used adjunctive test for evaluating patients with suspected ACL injuries. It is the most non-invasive method for assessing ACL fibers. The MRI can categorize ACL injuries in patients into two types, namely total/complete ACL tears and partial ACL tears.[14,15] The injury categories documented in this research were derived from the radiologist's interpretation of MRI scans conducted on patients listed in the medical records.

The analysis employed in this study included both univariate and bivariate analyses. Univariate analysis was undertaken to provide a depiction of the frequency distribution and percentage of each examined variable. The univariate analysis aims to explore sample characteristics, encompassing gender, age, BMI, and injury severity. Bivariate test were used to analyze the relationship between independent and dependent variables. In this study, both variables were measured on a categorical scale, necessitating a Chi-

Square test. In the Chi-Square test, a p-value of ≤ 0.05 indicated a significant influence of the independent variable on the dependent variable. Conversely, a p-value of > 0.05 suggested no significant influence of the independent variable on the dependent variable. This study utilized a cross-sectional design, enabling the calculation of the Odds Ratio (OR) to examine the exposure odds ratio between cases and controls. A value of OR > 1 signified a positive association, indicating that the variable elevated the risk in the exposed group. Conversely, a value of OR < 1 suggested a negative association, implying that the variable reduced the risk in the exposed group. A value of OR = 1 indicated equal disease occurrence between the exposed and unexposed groups, signifying no association between exposure and outcome.

**RESULT**

The patient characteristics including age, body mass index (BMI), gender, occupational history, severity level, and the patient's history of interventions presented in Table 1.

**Table 1.** Frequency Distribution of the ACL Injuries Patients at RSPAD Gatot Soebroto from January 2021 to December 2022

| Characteristics | Frequency | % |
|---|---|---|
| **Age** | | |
| Child (6 – 10 years old) | 0 | 0 |
| Adolescent (11 – 18 years old) | 9 | 7.4 |
| Adult (19 – 44 years old) | 107 | 88.4 |
| Pre-Elderly (45 – 59 years old) | 4 | 3.3 |
| Elderly (≥ 60 years old) | 1 | 0.8 |
| **Body Mass Index (BMI)** | | |
| Under-normal BMI (< 18,5 $Kg/m^2$) | 0 | 0 |
| Normal BMI (18,5 – 24,9 $Kg/m^2$) | 61 | 50.4 |
| Above-normal BMI (> 25 $Kg/m^2$) | 60 | 49.6 |
| **Gender** | | |
| Male | 105 | 86.8 |
| Female | 16 | 13.2 |
| **Occupational History** | | |
| Civilian | 60 | 49.6 |
| National Armed Forces (TNI) patients | 61 | 50.4 |
| **Severity Degree** | | |
| *Total tear* | 85 | 70.2 |
| *Partial tear* | 36 | 29.8 |
| **Treatment** | | |
| Operative | 121 | 100 |
| Non-operative | 0 | 0 |
| **Total** | **121** | **100** |

Based on the data presented in Table 1, the majority of patients who suffered ACL injuries at RSPAD Gatot Soebroto from January 2021 to December 2022 belonged to the adult age range (19–44 years), comprising 107 patients (88.4%). Additionally, the data revealed that most ACL injury patients have a normal BMI (18.5–24.9 kg/m2), comprising 61 patients (50.4%), which is nearly equal to patients with an above-normal BMI (>25 kg/m2), amounting to 60 patients (49.6%).

Table 1. also indicates that most ACL injury patients are male, with 105 patients (86.8%). Among the total sample, civilian patients comprised 60 (49.6%), and those affiliated with the TNI comprised 61 patients (50.4%). Most of ACL injury patients exhibited severity in the form of a total tear, totaling 85 patients (70.2%). All patients (121) included in the study received treatment for their injuries in the form of operative procedures (100%).

**Table 2.** Cross-tabulation and Bivariate Analysis Findings on Age, BMI, and Occupational History in Relation to the Severity Degree of Injuries

| Variable | Severity Degree | | | | Total | | *p-value* | OR |
|---|---|---|---|---|---|---|---|---|
| | *Total tear* | | *Partial Tear* | | | | | |
| | n | % | n | % | n | % | | |
| **Age** | | | | | | | | |
| Adolescent (11 – 18 years old) | 7 | 77.78 | 2 | 22.22 | 9 | 100 | 0.633 | 1.608 |
| Adult (19 – 44 years old) | 75 | 70.1 | 32 | 29.9 | 107 | 100 | | |
| Pre-Elderly (45 – 59 years old) | 2 | 50 | 2 | 50 | 4 | 100 | | |
| Elderly (≥ 60 years old) | 1 | 100 | 0 | 0 | 1 | 100 | | |
| **Total** | 85 | 70.25 | 36 | 29.75 | 121 | 100 | | |
| **Body Mass Index (BMI)** | | | | | | | | |
| Normal BMI (18.5 – 24.9 Kg/m$^2$) | 43 | 70.5 | 18 | 29.5 | 61 | 100 | 0.953 | 1.024 |
| Above-normal BMI (> 25 Kg/m$^2$) | 42 | 70 | 18 | 30 | 60 | 100 | | |
| **Total** | 85 | 70.25 | 36 | 29.75 | 121 | 100 | | |
| **Occupational History** | | | | | | | | |
| Civilian | 46 | 76.67 | 14 | 23.33 | 60 | 100 | 0.126 | 1.853 |
| National Armed Forces (TNI) | 39 | 63.94 | 22 | 36.06 | 61 | 100 | | |
| **Total** | 85 | 70.25 | 36 | 29.75 | 121 | 100 | | |

Table 2 shows that ACL injury severity, particularly total tears, is more prevalent in the adult age group (19–44 years) with 75 patients (70.1%). Despite an initial Chi-Square analysis indicating some cells violate the assumption, combining variables (Adolescent–Adult and Pre-Elderly–Elderly) and conducting Fisher's Exact test yields a p-value of 0.633. It suggests no significant association between age and ACL injury severity. The calculated Odds Ratio (OR) indicates a 1.608 times higher likelihood of total tear severity in ACL injuries for patients in the adolescent–adult age group compared to the pre-elderly–elderly age group, emphasizing a higher risk in the former.

Table 2 indicates that patients with a normal BMI (18.5–24.9 kg/m$^2$) and those with an above-normal BMI (>25) show similar frequencies of total tear severity at 70.5% and 70%, respectively. Both groups also exhibit an equal number of cases with partial tear severity (29.5% for normal BMI and 30% for above-normal BMI). Chi-Square analysis, employing a 2x2 table for BMI and injury severity, reveals no violation of test assumptions, with a significance value of 0.953 (>0.05). Hence, no significant relationship is found between BMI and ACL injury severity. The calculated Odds Ratio (OR) suggests that patients with an overweight BMI are 1.024 times more likely to experience total tear severity in ACL injuries compared to those with a normal BMI, indicating a slightly higher risk for the former group.

The data in Table 2 reveals that civilian ACL patients more frequently experience total tear injuries (76.67%, 46 patients) compared to National Armed Forces (TNI) patients (63.94%, 39 patients). Conversely, TNI patients are more prevalent in partial tear injuries (36.06%, 22 patients) compared to civilians (23.33%, 14 patients). Chi-square analysis, using a 2x2 table for occupational history and injury severity, shows no violation of test assumptions, with a significance value of 0.126 (>0.05). Hence, there is no significant relationship between occupational history and ACL injury severity. The calculated OR suggests TNI members are 1.853 times more likely to experience total tear severity in ACL injuries compared to civilians, indicating a higher risk for the TNI group.

## DISCUSSION

Bivariate analysis results examining the relationship between age, BMI, and occupational history with ACL injury severity reveal no significant correlation. It may be attributed to the majority of patients being distributed in a group that theoretically does not increase the risk of injury. The calculated correlation between age and severity yields no statistically significance value of 0.633 (p >0.05). It aligns with the Saud F et al. study on male athletes in Saudi Arabia, indicating no statistically significant association between age and ACL injury severity (p = 0.944).[16] Research by Torgutalp et al. also yielded a p-value of 0.25 (>0.05), indicating no statistically significant correlation between age and ACL injury severity.[17] The odds ratio (OR) analysis in this study shows that patients in the adolescent to adult age group are at a higher risk of total tear ACL injuries, possibly due to a larger number of patients in this age group compared to the pre-elderly to the elderly group. Therefore, these findings illustrate that advancing age, especially within the productive age category accompanied by increased activity, can elevate the risk of patients experiencing ACL injuries.[11]

The structural and functional capacity of the ACL diminishes with age, especially in patients aged 67-90 compared to those aged 40-50 and younger individuals (22-35). This decline is evident at the ligament cell level, showing increased tissue degeneration with age. Age-related changes in the ACL's extracellular matrix, particularly disruptions in collagen fibers, are more pronounced in young patients without cartilage degeneration or inflammation. Collagen fiber diameter reduction and an increase in small collagen fiber concentration intensify with age. This decline is associated with reduced Mkx levels in the ACL, a protein crucial for tenocyte cell differentiation and maintaining ligament and tendon cell function in adults. Despite Mkx expression in adult human tendon and ligament cells, its expression diminishes in ACL cells as age increases. Consequently, the decrease in Mkx within ACL cells, including annulus fibrosus and ligament-like cells in the intervertebral disc (IVD), leads to reduced gene expression of the extracellular matrix in ligaments.[6]

Calculations assessing the correlation between BMI and ACL injury severity show no statistically significant relationship, with a significance value of 0.953 (>0.05). The OR analysis shows that patients with a normal BMI have a higher risk of total tear ACL injuries, possibly because there are more patients in the normal BMI category compared to those with excess BMI. These findings align with a study by Saud F et al. (2021) study on male athletes aged 15 to 55 in Saudi Arabia, which also found no statistically significant relationship between BMI and ACL injury severity ($p = 0.341$).[16] However, the study also highlights that an increase in BMI above 19.9 Kg/m$^2$ elevates the risk of ACL injury.[12] Higher BMI increases mechanical pressure on the knee joint, elevating stress on the ACL.[18]

Higher axial compressive forces on the knee, combined with increased body weight, greater BMI, and a larger lateral posterior tibial slope, are suggested to elevate ACL strain and increase the risk of injury.[19] Excess body weight and obesity elevate mechanical loads on lower limb joints, affecting knee joint cartilage. Chronic knee compression for 20 weeks led to reduced cartilage thickness and cell count, along with notable histological degeneration and increased subchondral bone thickness. This structural damage causes abnormal joint loading, especially impacting the knees in obese individuals. Larger thigh circumference in obese patients triggers compensatory measures, such as increased hip abduction and varus malalignment in the knee, reducing contact area, and intensifying load on the medial articular cartilage, resulting in damage.[7]

The analysis of the relationship between the patient's occupational history and ACL injury severity shows no significant association, with a p-value of 0.126 (>0.05). This lack of significance may be attributed to a nearly equal distribution of patients with National Armed Forces (TNI) and civilian occupational histories, resulting in no substantial difference in the relationship between patients' occupational history and the severity of ACL injuries. Occupation is indeed a risk factor for ACL injuries, as more strenuous activities and heavier workloads can increase tissue stress levels. However, the data analysis in this study shows that fatigue has a more direct impact on ACL injuries than occupation. Fatigue can significantly affect decision-making and increase tissue stress, which can result in injury.[20]

Additionally, the results show that their occupational history does not directly influence the severity of ACL injuries in patients. Medical records indicate that patients sustained ACL injuries during sports activities unrelated to their profession. These sudden excessive and rapid increases in training loads or activities are likely responsible for a large proportion of non-contact soft-tissue injuries.[20] No prior research has explored the link between occupational history and ACL injury severity. The study's specific focus on military personnel versus civilians in relation to severity is unique, contributing to the absence of similar studies in these categories.

The odds ratio (OR) analysis reveals that patients in military professions face a higher risk of total tear ACL injuries. It aligns with the study by Torgutalp et al. (2020) study, which showed a higher prevalence of ACL injuries among patients engaging in recreational sports (74.4%) compared to professional athletes (25.6%). The data further indicates a higher incidence of complete tear severity in both groups (68.8% recreational, 31.3% professional) compared to partial tear (88.5% recreational, 11.5% professional). The analysis concludes a statistically significant relationship between patients' sports activity/history and the severity of ACL injuries.[17]

The ACL injuries are common in sports, leading to functional limitations and reduced activity levels. Engaging in high-risk sports with cutting and pivoting movements significantly increases the risk of ACL injuries.[21] The ACL injuries are frequently linked to sports with pivoting or twisting movements, like skiing, rugby, and soccer. They occur during actions such as planting, landing, cutting, and decelerating.[22] Many athletes get injured during forward movements or sudden changes in motion, especially when the knee is nearly fully extended and involved in a rotational movement.[23] The risk of severe ACL injuries is higher in

patients with intense physical activity, causing increased fatigue. While it doesn't directly affect ACL structure, fatigue impacts decision-making during activities. Muscle fatigue, a strength reduction from exercise, can occur due to changes in muscles and the central nervous system. It affects the nervous system's ability to relay knee information, impacting balance accurately. Consequently, patient fatigue leads to poor decision-making and a higher risk of severe injuries (total tear).[20]

This study's limitations include a cross-sectional design, limiting observation to a specific period, and the examination of relationships between dependent and independent variables. The relatively small sample size restricts the generalizability of results. The research relies solely on available medical records, lacking comprehensive data on patients' injury history, knee biomechanics during injury, and activities at the time of injury. Additionally, data on patients' daily activity levels are not recorded, making this variable unavailable for research. No prior studies in Indonesia have addressed the severity of ACL injury, resulting in a lack of literature for reference. It is hoped that future researchers will explore factors that exert greater influence on the severity of ACL injuries, such as levels of work fatigue, types of sports, and a wider range of variables, in order to uncover more factors associated with the severity of ACL injuries.

## CONCLUSION

There is no significant relationship between age, body mass index, employment history and the severity of ACL injuries. However, despite the lack of significant correlation, it is imperative to acknowledge their potential implications. These three risk factors might still contribute to an increased susceptibility to more severe ACL injuries, such as total tears.

A comprehensive comprehension of these relationships is paramount for devising efficacious preventive measures and targeted interventions aimed at mitigating ACL injury risks across diverse occupational settings. Further exploration of the intricate interplay between these factors and ACL injury severity could yield invaluable insights, guiding the development of tailored strategies for injury prevention and management in academic research.

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## CONFLICT OF INTEREST

The researchers affirm the absence of any conflict of interest in undertaking this study.

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