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Analysis Of Biomechanical Factors Contributing To ACL Injuries.

Utkarsha Dudhedia[1], Bhushan Salunke[1], Ashok Thorat[2], and Gopal Shinde[3]*.

[1]Orthopedic Surgeon, Class I , Civil Hospital, Nashik, Maharashtra, India.
[3]Civil Surgeon, Civil Hospital, Nashik, Maharashtra, India.
[4]Professor and Head of the Department, Department of Orthopedics, MPGIMER, MUHS, Nashik,

ABSTRACT

Anterior Cruciate Ligament (ACL) injuries pose a significant risk to individuals engaged in sports and physical activities, necessitating a thorough understanding of biomechanical factors contributing to injury susceptibility. Our study investigates the association between knee biomechanics, muscle activation, ground reaction forces, and the incidence of ACL injuries. A prospective cohort design with 40 participants was employed over a one-year duration. Biomechanical assessments, including knee flexion range, muscle activation (EMG), and ground reaction forces during cutting and jumping manoeuvres, were conducted. Follow-up assessments tracked ACL injury incidence. Statistical analyses, including hazard ratios, were utilized to determine associations. Reduced knee flexion range during cutting correlated inversely with ACL injury risk (hazard ratio = 0.92, 95% CI: 0.85-0.98), emphasizing the importance of proper knee biomechanics. Conversely, heightened muscle activation during jumps increased ACL injury risk (hazard ratio = 1.15, 95% CI: 1.02-1.30), highlighting the nuanced role of muscle function. Lower ground reaction forces during cutting were associated with increased injury risk (hazard ratio = 0.75, 95% CI: 0.61-0.92), emphasizing the significance of force absorption. This study provides insights into specific biomechanical factors influencing ACL injury susceptibility, informing targeted prevention strategies. Understanding these dynamics contributes to advancing sports medicine and enhancing injury prevention protocols.

Keywords: ACL injuries, Biomechanics, Muscle activation, Ground reaction forces.

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**Corresponding author*

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INTRODUCTION

Anterior Cruciate Ligament (ACL) injuries represent significantly and are prevalent, concern in the realm of sports and physical activity, posing a substantial risk to individuals across various age groups and athletic disciplines [1]. The ACL, a crucial ligament within the knee joint, plays a pivotal role in stabilizing the knee during movements such as pivoting, cutting, and jumping. Despite advancements in sports medicine and training techniques, ACL injuries continue to plague athletes, leading to prolonged rehabilitation periods and, in some cases, permanent impairment [2-4]. Understanding the biomechanical factors contributing to ACL injuries is paramount for devising effective preventive strategies. This analysis delves into the intricate interplay of factors, including neuromuscular control, ligamentous laxity, and biomechanical alignment, to shed light on the complexities that predispose individuals to ACL injuries. By unravelling these biomechanical intricacies, we aim to enhance injury prevention protocols and ultimately safeguard the well-being of athletes and active individuals engaged in dynamic physical pursuits [5, 6].

METHODOLOGY

The study employed a prospective cohort design to investigate the biomechanical factors contributing to ACL injuries. The sample comprised 40 participants, selected through a combination of convenience and purposive sampling from local sports clubs and recreational centres. Inclusion criteria encompassed individuals aged 18 to 40 years, actively engaged in sports or physical activities that involved frequent pivoting, cutting, or jumping. Exclusion criteria included a history of previous ACL injuries, knee surgery, or pre-existing musculoskeletal conditions that could potentially confound the study outcomes.

The study spanned a duration of one year, during which participants underwent baseline assessments to capture relevant demographic information, including age, gender, and sports participation history. Biomechanical assessments were conducted using motion capture systems, force plates, and three-dimensional analysis software. Participants were instructed to perform standardized movements replicating sports-related actions, such as cutting manoeuvres and jumps. Data collected during these assessments provided insights into knee joint kinematics, muscle activation patterns, and other relevant biomechanical parameters associated with ACL injury risk. Regular follow-up evaluations were conducted at specified intervals throughout the one-year period to track any incidence of ACL injuries and to further analyse biomechanical changes over time. Statistical analyses, including t-tests and regression models, were employed to identify significant associations between biomechanical factors and the occurrence of ACL injuries within the study cohort. The comprehensive methodology aimed to yield valuable insights into the dynamic interplay of biomechanics and ACL injury susceptibility over the course of the study.

RESULTS

Table 1: Demographic Characteristics of Study Participants

Variable	Mean (SD) or n (%)
Age (years)	28.5 (4.2)
Gender (Male/Female)	22/18
Sports Participation History	6.3 (3.1) years

Table 2: Baseline Biomechanical Parameters

Biomechanical Variable	Mean (SD) or Median (IQR)
Knee Flexion Range (degrees)	35.2 (4.8)
Muscle Activation (EMG) during cutting	85.6 (12.3)
Ground Reaction Force during jumps (N)	1100 (200)

Table 3: Follow-up Assessment - Incidence of ACL Injuries

Time Point (Months)	Number of ACL Injuries (n)	Incidence Rate (%)
3	2	5.0
6	1	2.5
9	3	7.5
12	4	10.0

Table 4: Association between Biomechanical Factors and ACL Injuries

Biomechanical Variable	Hazard Ratio (95% CI)	p-value
Knee Flexion Range during cutting	0.92 (0.85-0.98)	0.015
Muscle Activation (EMG) during jumps	1.15 (1.02-1.30)	0.028
Ground Reaction Force during cutting	0.75 (0.61-0.92)	0.007

Note: SD - Standard Deviation; IQR - Interquartile Range; EMG - Electromyography; CI - Confidence Interval.

DISCUSSION

Our study results indicate that several biomechanical factors are significantly associated with the risk of ACL injuries. Notably, a reduced knee flexion range during cutting manoeuvres was found to be inversely related to ACL injury risk. This finding aligns with previous research emphasizing the importance of proper knee biomechanics in injury prevention. Adequate knee flexion allows for better shock absorption and dissipates the forces experienced during dynamic movements, potentially reducing the strain on the ACL. The observed hazard ratio of 0.92 (95% CI: 0.85-0.98) suggests that a one-degree increase in knee flexion range is associated with an 8% lower risk of ACL injury. These results underscore the significance of incorporating knee flexion training programs into injury prevention strategies, especially for individuals engaged in sports requiring frequent cutting actions [7, 8].

Conversely, increased muscle activation, as measured by electromyography (EMG), during jumping activities was identified as a risk factor for ACL injuries. This unexpected finding suggests that heightened muscle activation, possibly leading to altered joint loading patterns, may contribute to increased vulnerability of the ACL. The hazard ratio of 1.15 (95% CI: 1.02-1.30) implies that a 15% increase in muscle activation is associated with a higher ACL injury risk. While the exact mechanisms behind this association warrant further investigation, these results emphasize the intricate relationship between muscle function and ACL integrity. It calls for a nuanced approach to muscle training, focusing not only on strength but also on optimal neuromuscular control to mitigate injury risk [9].

Impact of Ground Reaction Forces on ACL Injury Susceptibility

Ground reaction forces (GRF) during cutting manoeuvres emerged as another crucial factor influencing ACL injury risk. The study revealed that a lower GRF was associated with an increased hazard of ACL injuries, with a hazard ratio of 0.75 (95% CI: 0.61-0.92). This implies that a 25% reduction in GRF is associated with a higher risk of ACL injury. These findings suggest that inadequate force absorption during cutting actions may expose the knee joint to higher stress and strain, contributing to ACL injury susceptibility. Athletes and coaches should consider incorporating training programs aimed at improving force absorption and distribution during sports-specific movements to mitigate the risk of ACL injuries.

Temporal Patterns of ACL Injuries

The study's follow-up assessments revealed a time-dependent pattern in the incidence of ACL injuries. The highest incidence rate was observed at the 12-month mark, with 10% of participants experiencing ACL injuries. This temporal trend underscores the dynamic nature of ACL injury risk and suggests that preventive interventions should be implemented continuously, with particular attention paid to peak vulnerability periods. The fluctuating incidence rates at different time points also highlight the need for personalized and adaptive injury prevention strategies that consider individual biomechanical profiles and evolving risk factors over time [10].

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While the study provides valuable insights into biomechanical factors associated with ACL injuries, several limitations should be acknowledged. The relatively modest sample size of 40 participants may limit the generalizability of the findings to broader populations. Additionally, the study focused on specific biomechanical variables, and other factors, such as genetic predispositions and hormonal influences, were not extensively explored. Future research should aim for larger and more diverse samples, incorporating a comprehensive range of potential contributing factors to enhance the understanding of ACL injury mechanisms.

CONCLUSION

In conclusion, our study elucidates the intricate relationship between biomechanical factors and ACL injury susceptibility. The findings underscore the importance of knee flexion range, muscle activation patterns, and ground reaction forces in influencing ACL injury risk. These insights contribute to the evolving landscape of injury prevention strategies, emphasizing the need for targeted interventions addressing specific biomechanical vulnerabilities. As sports medicine continues to advance, integrating these findings into comprehensive training programs holds promise for reducing the burden of ACL injuries and promoting the long-term health and performance of athletes.

REFERENCES

[1] J Agel, EA Arendt, B Bershadsky. Anterior cruciate ligament injury in national collegiate athletic association basketball and soccer: a 13-year review, Am J Sports Med 2005; 33:524-530.
[2] E Arendt, R Dick. Knee injury patterns among men and women in collegiate basketball and soccer. NCAA data and review of literature. Am J Sports Med 1995; 23:694-701.
[3] PJ McNair, RN Marshall, JA Matheson. Important features associated with acute anterior cruciate ligament injury, N Z Med J 1990; 103:537-539.
[4] BP Boden, GS Dean, JA Feagin Jr, WE Garrett Jr. Mechanisms of anterior cruciate ligament injury. Orthopedics 2000; 23:573-578.
[5] JA Feagin Jr, KL Lambert. Mechanism of injury and pathology of anterior cruciate ligament injuries. Orthop Clin North Am 1985; 16: 41-45.
[6] Caraffa G, Cerulli M, Projetti G, Aisa A, Rizzo, Prevention of anterior cruciate ligament injuries in soccer. A prospective controlled study of proprioceptive training. Knee Surg Sports Traumatol Arthrosc 1996; 4:19-2.
[7] TE Hewett, TN Lindenfeld, JV Riccobene, FR Noyes. The effect of neuromuscular training on the incidence of knee injury in female athletes. A prospective study. Am J Sports Med 1999; 27: 699-706.
[8] MC Tayade. Role of data mining techniques in healthcare sector in India. Sch J App Med Sci 1 (3): 158-60.
[9] BR Mandelbaum, et al. *E*ffectiveness of a neuromuscular and proprioceptive training program in preventing anterior cruciate ligament injuries in female athletes: 2-year follow-up. Am J Sports Med 2005;33:1003-1010.
[10] RA Malinzak, SM Colby, DT Kirkendall, B Yu, WE Garrett. A comparison of knee joint motion patterns between men and women in selected athletic tasks. Clin Biomech 2001;16:438-445.