Body Sway Analysis in Basketball Players Post-ACL Reconstruction Versus Healthy Individuals

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Abstract

Anterior cruciate ligament (ACL) injuries are prevalent among athletes, particularly in basketball, impacting balance and postural stability. This study aimed to compare body sway characteristics between basketball players post-ACL reconstruction and healthy controls. A total of twenty participants, ten post-ACL reconstruction and ten age- and sex-matched healthy individuals, were assessed using a Kistler force plate under open and closed-eye conditions. The center of gravity (COG) sway was measured during a unilateral stance in an injured posture. Results indicated that the operated limb demonstrated significantly greater COG displacement than both the non-operated limb of the same group and the dominant limb of the control group across all measured variables. These findings suggest a marked impairment in balance control in basketball players following ACL reconstruction, attributed to reduced proprioceptive feedback from the injured limb. Improved proprioceptive training and rehabilitation protocols are essential for enhancing postural stability in these athletes. Further research is warranted to investigate the long-term recovery of balance and the role of proprioceptive training in optimizing post-surgery rehabilitation outcomes.

Keywords: Anterior cruciate ligament, body sway, balance, rehabilitation, basketball players

Introduction

ACL injuries are among the most common sports-related injuries, especially in sports demanding rapid directional changes and jumping, such as basketball. The prevalence of ACL injuries is significant, with estimates ranging from 100,000 to 200,000 cases annually in the United States alone (Levy, 2010). Athletes, particularly basketball players, are particularly susceptible, as approximately 53% of ACL injuries occur within this population (Siegel, 2012). The surgical intervention known as ACL reconstruction (ACLR) aims to restore knee stability and allow athletes to return to their pre-injury activity levels. Despite advancements in surgical techniques and rehabilitation protocols, achieving complete recovery remains challenging. The recovery phase not only impacts physical health but also imposes financial and psychological burdens on individuals (Hootman et al., 2007). A substantial body of research highlights the importance of proprioception in maintaining balance and preventing re-injury following ACLR. Proprioceptive deficits are commonly observed in individuals post-surgery, contributing to instability during functional movements (Henriksson et al., 2001). Understanding the mechanics of body sway post-ACLR is crucial for developing effective rehabilitation strategies. This study aims to quantify the differences in body sway between basketball players who have undergone ACL reconstruction and healthy controls, thereby providing insights into post-surgery rehabilitation effectiveness. The anterior cruciate ligament is vital for knee joint stability, and its rupture can lead to significant impairments in proprioceptive function, which is crucial for maintaining balance during athletic activities. The consequences of ACL injuries extend beyond physical limitations; they can also lead to psychological challenges, including anxiety and fear of re-injury, which may further complicate the rehabilitation process. Research indicates that a substantial percentage of ACL injuries occur due to non-contact mechanisms, often exacerbated by poor neuromuscular control (Hirokazu et al., 2010). Post-ACLR, athletes often experience altered biomechanics, leading to compensatory movement patterns that can increase the risk of secondary injuries. Studies suggest that individuals with a history of ACL injuries exhibit compromised postural control, as evidenced by increased body sway during static and dynamic tasks (Bonfim et al., 2008). Furthermore, proprioception, or the body's ability to perceive its position in space, plays a pivotal role in maintaining balance. Following ACLR, the loss of proprioceptive feedback from the injured limb may result in an increased degree of body sway, posing challenges for athletes during recovery (Ardern et al., 2011). Despite advancements in surgical techniques and rehabilitation practices, the nuances of balance recovery post-ACLR remain poorly understood. Previous literature has demonstrated varying degrees of success in restoring balance and proprioception, highlighting the need for further research. This study aims to compare the body sway characteristics of basketball players following ACL reconstruction with healthy controls, focusing on how injury status influences balance control.

Methodology

This cross-sectional study involved twenty basketball players, comprising ten individuals who had undergone ACL reconstruction (mean age 23±2 years; height 180±4 cm; weight 75.12±5.35 kg) and ten healthy, age- and sex-matched controls (mean age 23±2.4 years; height 180±4.35 cm; weight 74.62±3.1 kg). The participants were recruited after an average recovery period of nine months post-ACLR and were fully engaged in competitive sports activities. The inclusion criteria for the study mandated that participants had undergone a single ACL surgical procedure without additional ligament injuries or prior knee surgeries. Exclusion criteria included neurological disorders, a history of severe knee injuries, and any factors that could limit activity in the six weeks preceding testing. Postural stability assessments were performed using a Kistler force plate, measuring center of gravity (COG) sway in a unilateral stance under both open and closed-eye conditions. Each participant completed three trials in randomized order to mitigate learning or fatigue effects, standing barefoot and focusing on a fixed point one meter away. The tests lasted for 30 seconds, and breaks were provided between trials. The measured parameters included COG displacement, velocity, and sway in both the anterior-posterior and medial-lateral axes. Data were analyzed using SPSS software (version 20), applying the Kolmogorov-Smirnov test for normality. Paired t-tests were utilized to compare the operated and non-operated limbs within the case group, while independent t-tests compared the case and control groups.

Results

The results indicate notable differences in COG sway between the operated side (OS) and non-operated side (NOS) in the case group, as well as when compared to the control group's dominant limb (Table 1).

Table 1: COG Displacement in the Case Group and Control Group

Variables	Mean Difference ± SD	95% Confidence Interval	p-value
Opened Eyes			
Displacement (ant-post axis)	5.76 ± 1.13	4.12 - 7.74	0.001
Displacement (med-lat axis)	1.75 ± 1.47	-4.96	0.002
Total velocity (cm/sec)	0.79 ± 0.29	0.28 - 1.16	0.007
Closed Eyes			
Displacement (ant-post axis)	5.54 ± 1.56	3.72 - 7.99	0.001
Displacement (med-lat axis)	0.57 ± 0.11	-3.25	0.02
Total velocity (cm/sec)	0.57 ± 0.21	0.04 - 1.06	0.05

The operated side exhibited greater displacement across all measurements compared to both the non-operated side and the control group's dominant side, suggesting compromised balance and stability (Table 2 and Table 3).

Table 2: COG Displacement Comparison Between Case and Control Group (Operated Side)

Variables	Mean Difference ± SD	95% Confidence Interval	p-value
Opened Eyes			
Displacement (ant-post axis)	5.32 ± 1.107	4.74 - 8.06	0.001
Displacement (med-lat axis)	1.75 ± 1.47	2.72 - 7.34	0.001
Total velocity (cm/sec)	0.79 ± 0.29	1.18 - 2.28	0.001
Closed Eyes			
Displacement (ant-post axis)	5.54 ± 1.56	4.59 - 9.72	0.001
Displacement (med-lat axis)	0.57 ± 0.11	2.21 - 5.07	0.005
Total velocity (cm/sec)	0.57 ± 0.21	1.04 - 1.06	0.001

Table 3: COG Displacement Comparison Between Non-Operated Side of Case Group and Dominant Side of Control Group

Variables	Mean Difference ± SD	95% Confidence Interval	p-value
Opened Eyes			
Displacement (ant-post axis)	5.76 ± 1.13	-2.66	0.94
Displacement (med-lat axis)	1.75 ± 1.47	-8.96	0.05
Total velocity (cm/sec)	0.79 ± 0.29	-2.44	0.001
Closed Eyes			
Displacement (ant-post axis)	5.54 ± 1.56	1.06 - 2.23	0.001
Displacement (med-lat axis)	0.57 ± 0.11	-2.37	0.02
Total velocity (cm/sec)	0.57 ± 0.21	0.44 - 2.62	0.03

Discussion

The findings of this study reveal significant differences in balance control between basketball players who have undergone ACL reconstruction and their healthy counterparts. The greater COG displacement observed in the operated limb of the ACLR group suggests impaired postural stability, corroborating previous research indicating that ACL injuries often lead to prolonged deficits in balance and proprioception (Hewett et al., 2006). The study found that the operated limb exhibited considerable sway in both eyes-open and eyes-closed conditions, indicating that visual input does not completely compensate for the proprioceptive deficits associated with ACL injuries. The increased COG sway during unilateral stance highlights the need for targeted rehabilitation protocols focusing on proprioceptive training to restore balance (Katz et al., 2013). Interestingly, the non-operated limb of the ACLR group also demonstrated increased sway when compared to the control group. This finding aligns with the hypothesis that the body may rely on compensatory mechanisms following ACL injury, leading to alterations in motor control that can impair balance in the uninjured limb (Zarins et al., 2008). The implications of these findings suggest that athletes may benefit from comprehensive rehabilitation programs that not only focus on the injured limb but also address overall balance and proprioception. These results underscore the necessity of continuous monitoring of balance capabilities during the rehabilitation process and the incorporation of specific balance training exercises into rehabilitation regimens. Previous studies have reported that proprioceptive training can significantly enhance postural stability and reduce the risk of re-injury (Griffin et al., 2011). Therefore, rehabilitation protocols should integrate dynamic balance exercises, functional training, and agility drills aimed at improving overall proprioceptive feedback and neuromuscular control. The limitations of this study include the small sample size and the lack of longitudinal follow-up to assess long-term recovery of balance. Future research should explore the effectiveness of various rehabilitation techniques, such as balance training modalities, in promoting recovery of proprioception and postural stability in ACLR patients.

Conclusion

In conclusion, basketball players post-ACL reconstruction exhibit significant balance impairments characterized by increased body sway, especially in the operated limb. The study highlights the importance of enhancing proprioceptive feedback during the rehabilitation process to improve overall balance control. Further research is needed to develop evidence-based rehabilitation protocols that prioritize both the injured and non-injured limbs, as well as to evaluate the long-term effects of balance training interventions. Future studies should consider larger sample sizes and diverse populations, including female athletes and various sports, to broaden the understanding of balance recovery post-ACL injury. Furthermore, investigating the impact of specific proprioceptive training modalities on balance and re-injury rates would provide valuable insights into optimizing rehabilitation practices for athletes recovering from ACL injuries.

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