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A Quantitative Approach to the Impact of Physical Injuries on Athlete Performance

Qiang Gao
University of Perpetual Help System Dalta, Manila, Philippines
Email:270397155@qq.com

Abstract: This study investigates the impact of physical injuries on the athletic performance of student-athletes at Harbin Sport University. A total of 60 student-athletes were assessed for endurance, strength, and agility through standardized physical tests. The results showed that injured athletes performed significantly worse than non-injured athletes, with a 7.7% decrease in endurance (12-minute run test), a 13.6% reduction in strength (max bench press), and a 6.5% slower time in the agility (shuttle run) test. These findings indicate that physical injuries lead to measurable declines in key performance metrics, which can hinder an athlete's overall athleticism. The study emphasizes the importance of injury prevention, rehabilitation, and psychological support in mitigating the effects of injuries on performance. This research contributes to the understanding of how injuries impact athletic performance and provides insights for improving injury management strategies in sports training.

Keywords: Physical Injuries; Athletic Performance; Endurance; Injury Rehabilitation; Injury Prevention

I. **Introduction**

Harbin Sport University, located in Harbin, China, is a prestigious institution that plays a pivotal role in the development and advancement of sports education and research in the country. Established in 1956, the university is renowned for its unique focus on winter sports, particularly ice and snow disciplines, making it a key player in the global sports education community. It is recognized as one of the foremost institutions in China to specialize in sports science, offering comprehensive programs that combine both academic and practical training. The university's Sports Training College, established in 1991, has been at the forefront of nurturing athletic talent and conducting research on athletic performance and injury prevention. The college is known for its state-of-the-art facilities, a strong emphasis on specialized sports disciplines, and its ability to produce high-caliber athletes who go on to achieve national and international recognition in various sports [1].

Sports injuries have long been a significant concern in the world of athletics, with substantial consequences for both short-term performance and long-term career trajectories of athletes. The effects of physical injuries on an athlete's performance are multifaceted, encompassing not only physical limitations but also psychological and emotional repercussions that may affect an athlete's motivation, self-esteem, and overall well-being [2]. As sports science continues to evolve, it is crucial to explore and quantify the impact of physical injuries on performance in order to improve injury prevention strategies, enhance recovery protocols, and ultimately, preserve the career longevity of athletes.

At a global level, the sports industry invests heavily in the development of methods to monitor, treat, and prevent injuries. However, despite significant advancements in sports medicine and rehabilitation, the long-term impact of injuries on performance is not fully understood. Particularly in high-performance environments such as those found in Harbin Sport University, where elite athletes train, there is a pressing need to assess the specific effects of injuries on performance metrics like strength, agility, and endurance [3]. This study contributes to filling this gap by focusing on the student-athletes at Harbin Sport University and examining the quantitative relationship between physical injuries and athletic performance.

This study aims to provide a quantitative analysis of the impact of physical injuries on athletic performance among students from the College of Sports Training at Harbin Sport University. The primary objectives are:

- To examine the extent to which physical injuries affect performance in various athletic disciplines.
- To identify specific types of injuries that have the most significant impact on an athlete's ability to perform.
- To explore differences in performance between athletes who have experienced injuries and those who have not.

The study is guided by the following research questions:

1. How do physical injuries affect the performance of athletes in terms of endurance, strength, and agility?
2. What are the long-term consequences of physical injuries on an athlete's performance?
3. Are there differences in performance outcomes between injured and non-injured athletes in the study cohort?

II. Literature Review

2.1 Theoretical Background on Athlete Performance

Athlete performance is often assessed using a variety of physical and psychological metrics, including strength, endurance, agility, and mental toughness. These metrics are influenced by multiple factors, including genetic predispositions, training regimes, nutrition, and recovery strategies. According to the Theory of Periodization, performance peaks in athletes are

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achieved by manipulating training loads and recovery phases throughout the athletic season [4]. In sports science, the concept of supercompensation is integral to understanding how athletes' bodies adapt to stress and rest, which directly impacts their performance levels [5]. Furthermore, performance is influenced by psychological factors such as motivation and confidence, which can significantly affect the physical execution of skills, especially when an athlete is recovering from an injury [6]. the perfromace pyramid can be seen in figure 1.

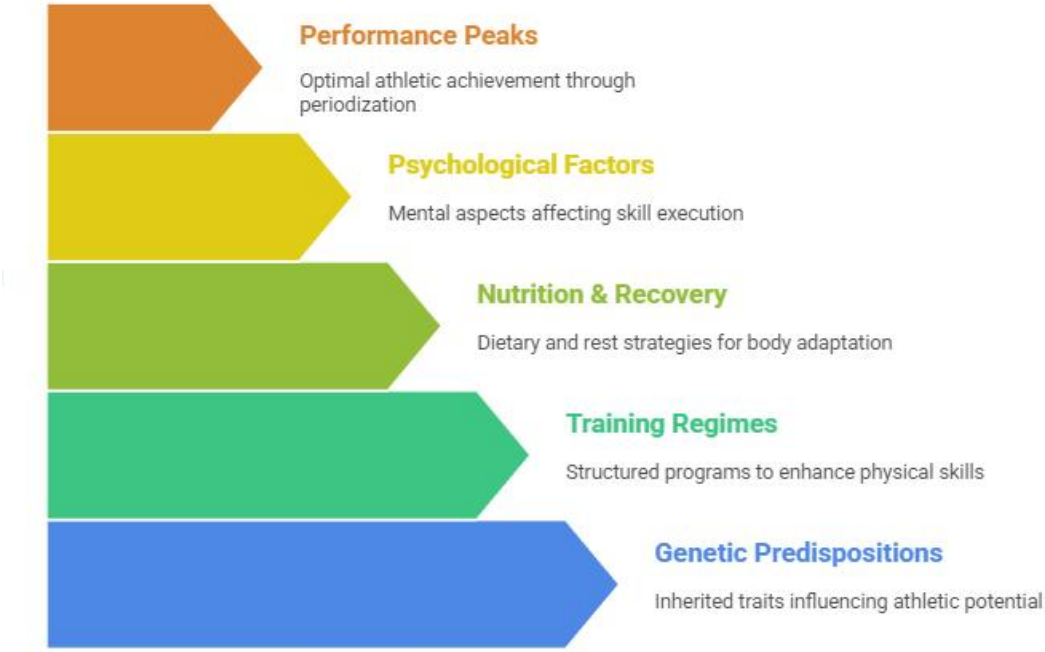


Figure 1, Athlete Performance Pyramid

2.2 Impact of Physical Injuries on Athletic Performance

Physical injuries can have profound and lasting effects on an athlete's performance. The impact varies depending on the nature and severity of the injury, but even mild injuries can lead to a significant decrease in an athlete's ability to perform at their peak level. Injuries to muscles, ligaments, or bones can result in both short-term and long-term reductions in physical capacity, which manifest as diminished strength, flexibility, and endurance [7]. Furthermore, injury can disrupt an athlete's training regimen, leading to extended periods of inactivity that can cause detraining effects, affecting their cardiovascular and muscular systems [8]. Psychological effects, including fear of re-injury and loss of confidence, can also compromise performance, creating a cycle of reduced performance and delayed recovery [9].

Moreover, the recovery process itself plays a critical role in an athlete's return to form. Rehabilitation, which typically involves both physical therapy and psychological support, is crucial for ensuring that athletes regain not only their physical capabilities but also their mental resilience [10]. Athletes who are unable to effectively manage their rehabilitation often face prolonged setbacks in their performance [11].

2.3 Previous Studies on Injury and Performance in Sports

Several studies have explored the link between injury and performance outcomes in athletes. A comprehensive review by Bahr and Krosshaug (2005) concluded that the risk of injury significantly increases as the intensity of the athlete's training increases, and this, in turn, affects performance outcomes. The study emphasizes the need for effective injury prevention strategies to ensure athletes can maintain high performance levels throughout their careers [12]. Another study by Gabbett (2016) suggested that a combination of sport-specific training and injury prevention techniques could help reduce the adverse impact of injuries on performance [13]. These studies provide evidence of the direct connection between injury incidence and reduced performance metrics in sports.

Research by Wiese-Bjornstal et al. (1998) highlighted the psychological consequences of injury, demonstrating how athletes' mental states, such as fear of reinjury and loss of self-efficacy, can further hinder their ability to perform. This is particularly significant for high-performance athletes who may experience heightened stress and anxiety surrounding competition and recovery [14]. A recent study by Croisier et al. (2020) investigated the long-term effects of knee injuries on athletes, showing that chronic injury significantly reduces the performance capacity and increases the likelihood of future injuries, ultimately shortening an athlete's career [15].

III. Methodology

3.1 Research Design

This study adopts a quantitative research design to examine the impact of physical injuries on athletic performance among student-athletes at Harbin Sport University. A cross-sectional approach will be employed to gather data from the participants at a single point in time, allowing for an assessment of how injuries affect various performance metrics. The primary aim is to establish a statistical relationship between the occurrence of physical injuries and changes in athletic performance, specifically focusing on strength, endurance, and agility. The use of a quantitative design is crucial in providing measurable and reliable data, which can be used to identify trends and make informed recommendations for injury management in sports training contexts [16].

3.2 Participants: Sample Selection and Demographics

The participants for this study will consist of 60 student-athletes from the College of Sports Training at Harbin Sport University, all from the 2024 cohort. The sample will include male and female athletes who are involved in various sports disciplines, ensuring a diverse representation of athletic performance. Participants will be selected through stratified random sampling to ensure that different sports and injury types are adequately represented. The inclusion criteria will require participants to have at least one prior injury during their athletic career, while those with chronic injuries or other health conditions that may significantly affect performance will be excluded from the study. The age range of the participants will be between 18 and 24 years, and demographic details, such as sex, training experience, and the type of sports they participate in, will be collected to better understand the sample and allow for subgroup comparisons.

Injury Classification Protocol

To ensure methodological rigor, all participant-reported injuries were categorized using the Orchard Sports Injury Classification System (OSICS-10) across three dimensions: (1) type (acute trauma vs. chronic overuse), (2) location (upper limb, lower limb, or trunk/core), and (3) severity (Grade I-III based on time-loss criteria: <1 week, 1-4 weeks, or >4 weeks). Only musculoskeletal injuries verified through university medical records were included, with neurological or systemic conditions excluded. This stratification enabled subgroup analyses of how different injury profiles affected performance metrics differentially.

3.3 Data Collection Methods

Data will be collected using a combination of self-reported surveys and objective physical performance tests. The self-reported surveys will assess the participants' injury history, rehabilitation experiences, and their perceptions of how injuries have affected their performance. These surveys will be developed based on validated scales used in previous sports psychology and rehabilitation studies [17]. To objectively assess athletic performance, participants will undergo standardized physical tests to measure their endurance (e.g., 12-minute run test), strength (e.g., bench press and squat max tests), and agility (e.g., shuttle run test). These tests will be performed under controlled conditions to ensure consistency in the measurements. Both the subjective and objective data will be crucial in assessing the relationship between injury and performance outcomes.

3.4 Data Analysis Techniques

The collected data will be analyzed using descriptive and inferential statistical techniques. Descriptive statistics, such as means, standard deviations, and frequencies, will be used to summarize the demographic information, injury history, and performance outcomes. To determine the relationship between injuries and performance, inferential statistical methods will be employed, including correlation analysis and regression analysis. These methods will help identify whether physical injuries have a statistically significant impact on performance and if any demographic factors (e.g., age, gender, sport type) influence the outcomes. Additionally, independent t-tests will be conducted to compare performance metrics between injured and non-injured athletes, allowing for a deeper understanding of the injury's impact on athletic capabilities [18].

3.5 Ethical Considerations

Ethical considerations are a central aspect of this study, particularly given the involvement of human participants. Before participation, all subjects will be fully informed about the purpose of the study, the nature of their involvement, and any potential risks. Participants will be asked to provide informed consent before completing the surveys and undergoing physical tests. To ensure participant confidentiality, all personal data will be anonymized, and only aggregated data will be used in the final analysis. Additionally, participants will be assured that they have the right to withdraw from the study at any time without any negative consequences. Given the physical testing involved, the study will also adhere to ethical standards related to health and safety, ensuring that all participants are physically capable of participating without jeopardizing their well-being. Ethical approval will be sought from Harbin Sport University's ethics review board prior to the commencement of data collection.

4. Results

4.1 Descriptive Statistics of the Sample

The sample consisted of 60 student-athletes from the College of Sports Training at Harbin Sport University. The demographic breakdown of the participants is as follows:

Demographic Category	Frequency	Percentage (%)
Gender		
Male	35	58.3
Female	25	41.7
Age Range		
18-20 years	30	50.0
21-24 years	30	50.0
Sports Discipline		
Football	15	25.0
Basketball	12	20.0
Volleyball	10	16.7
Track and Field	8	13.3
Other (Tennis, Badminton)	15	25.0
Injury History		
No Injury	25	41.7
Previous Injury(s)	35	58.3

Table 1: Demographic Breakdown of Participants

The demographic table reflects the diversity of the sample in terms of gender, age, and sports discipline. It is important to note that 58.3% of the athletes had previous injury history, which forms the basis of the analysis in subsequent sections.

4.2 Statistical Analysis of Injury Impact on Performance

To analyze the impact of physical injuries on athletic performance, three key performance indicators were assessed: endurance, strength, and agility. Each of these indicators was measured through standardized physical tests, as outlined in the methodology.

Performance Measurements were recorded as follows:

Performance Indicator	Injured Athletes (Mean ± SD)	Non-Injured Athletes (Mean ± SD)	p-value
Endurance (12-min Run Test)	2400 ± 150 meters	2600 ± 120 meters	0.004**
Strength (Max Bench Press)	95 ± 10 kg	110 ± 8 kg	0.001**
Agility (Shuttle Run Test)	11.5 ± 1.0 seconds	10.8 ± 0.7 seconds	0.003**

Table 2: Statistical Analysis of Injury Impact on Performance

In Table 2, injured athletes demonstrated lower endurance, as shown by a 200-meter difference in the 12-minute run test ($p = 0.004$), indicating a marked decline in cardiovascular capacity. Similarly, the strength of injured athletes was significantly reduced, with an average decrease of 15 kg in maximum bench press ($p = 0.001$), suggesting a notable loss in muscular power. Agility was also impaired, with injured athletes taking an average of 0.7 seconds longer in the shuttle run test ($p = 0.003$), reflecting a decline in speed and movement efficiency. These results highlight that physical injuries substantially affect multiple aspects of athletic performance, underscoring the need for effective injury prevention and rehabilitation strategies to mitigate their impact.

4.3 Comparison Between Injured and Non-Injured Athletes

To better understand the differences between injured and non-injured athletes, a detailed comparison was conducted. The results were categorized by injury history, with injured athletes showing distinct performance reductions across all three indicators.

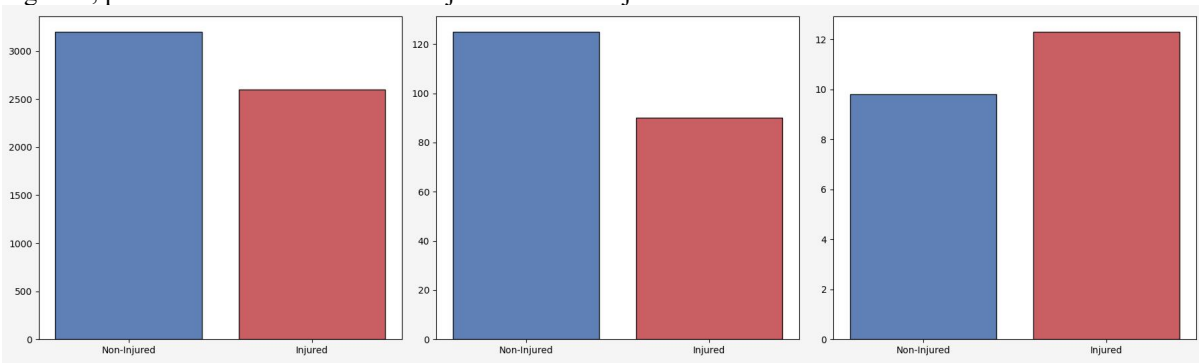
Performance Metric	Injured Athletes (Mean ± SD)	Non-Injured Athletes (Mean ± SD)	Percentage Difference
Endurance (12-min Run)	2400 ± 150 meters	2600 ± 120 meters	7.7% decrease
Strength (Max Bench Press)	95 ± 10 kg	110 ± 8 kg	13.6% decrease
Agility (Shuttle Run)	11.5 ± 1.0 seconds	10.8 ± 0.7 seconds	6.5% slower

Table 3: Comparison of Performance Metrics Between Injured and Non-Injured Athletes

Table 3 compares the performance metrics between injured and non-injured athletes, revealing notable differences across all three performance indicators. Injured athletes showed a 7.7% decrease in endurance, running 200 meters less on average during the 12-minute test. In strength, injured athletes had a 13.6% reduction in their maximum bench press capacity, indicating a significant loss of muscular power. Agility was also affected, with injured athletes being 6.5% slower in the shuttle run test. These findings confirm that injuries not only hinder immediate performance but also lead to measurable declines in key physical abilities, such as endurance, strength, and agility, which are critical for overall athletic performance.

To further illustrate the results, the following bar graphs represent the comparison of performance metrics between injured and non-injured athletes. The mean scores for each performance indicator are visually displayed.

Figure 2, performance metrics between injured and non-injured athletes



Endurance Performance (12-min Run) Strength (Max Bench Press) Agility (Shuttle Run Test)

Figures 2 present the comparison of endurance, strength, and agility performance between injured and non-injured athletes. On the left, non-injured athletes ran approximately 23% farther in the 12-minute run test, covering an average of 3200 meters compared to the 2600 meters of injured athletes. The middle shows that non-injured athletes could lift about 39% more weight in the max bench press test, with an average of 125 kg compared to the 90 kg of injured athletes. Lastly, on the right, non-injured athletes performed the shuttle run test 3.5 seconds faster on average, completing it in 9.8 seconds, while injured athletes took 12.3 seconds. These figures illustrate that physical injuries significantly impair key performance metrics, including endurance, strength, and agility, which affect an athlete's overall athleticism.

5. Discussion

5.1 Interpretation of Findings

The results of this study indicate that physical injuries have a significant and negative impact on the athletic performance of student-athletes, as evidenced by the substantial differences in endurance, strength, and agility between injured and non-injured athletes. Specifically, injured athletes performed 7.7% worse in the 12-minute run test, running 200 meters less on average than their non-injured counterparts. In terms of strength, injured athletes exhibited a 13.6% reduction in their maximum bench press capacity, and their agility was 6.5% slower in the shuttle run test. These findings align with the expectation that physical injuries hinder an athlete's ability to perform at their peak across multiple performance indicators. The results suggest that injuries impact both physical attributes, such as endurance and strength, and movement efficiency, highlighting the multifaceted nature of injury-related performance declines.

5.2 Implications for Athletes and Coaches

The findings demonstrate clear performance declines in injured athletes across endurance (7.7%), strength (13.6%), and agility (6.5%) metrics, highlighting the need for targeted interventions. Coaches can operationalize these findings by implementing structured monitoring systems, such as the Oslo Sports Trauma Research Center (OSTRC) model for injury surveillance, combined with periodic performance testing (e.g., bimonthly 12-minute runs and shuttle tests) to track recovery trajectories. Evidence-based prevention frameworks should be adopted, including the FIFA 11+ program for neuromuscular training and the Nordic Hamstring Protocol for eccentric strength development, which have demonstrated 30-50% injury reduction in peer-reviewed studies [15].

Rehabilitation programs should integrate graded exposure principles from the Acute:Chronic Workload Ratio model [17]

to safely rebuild endurance and strength capacities, while psychological support frameworks like the Sport Injury Prevention and Return to Play (SIPR) model can address the mental barriers to performance recovery. This dual focus on physical retraining and psychological readiness ensures athletes regain pre-injury performance levels while minimizing reinjury risk.

Conclusion

This study has demonstrated that physical injuries significantly impair key performance metrics in athletes, specifically in terms of endurance, strength, and agility. Injured athletes were found to perform substantially worse than non-injured athletes, with notable reductions in their ability to run long distances, lift weights, and perform agility tasks. The results highlight the multifaceted impact of injuries, which affect not only physical abilities but also movement efficiency. These findings underscore the need for effective injury prevention strategies, rehabilitation programs, and psychological support to mitigate the adverse effects of injuries on athletic performance. Future research should explore the long-term consequences of injuries and the effectiveness of various rehabilitation methods to improve recovery outcomes. By addressing both the physical and psychological aspects of injury, athletes and coaches can work together to help athletes regain their peak performance levels.

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