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Biomechanics Education and Injury Prevention Among School-Level Athletes and Coaches: An Empirical Assessment of Knowledge, Application, Confidence, And Training Practices

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Abstract

Biomechanics plays a critical role in enhancing sports performance, refining movement techniques, and reducing injury risk among athletes. Despite its recognized importance, biomechanics education remains inconsistently integrated into school-level sports training programs. The present study investigated the current state of biomechanics education among school-level athletes and coaches, focusing on biomechanics knowledge, injury prevention awareness, confidence, practical application, perceived importance, and learning preferences. A quantitative survey design was employed involving 987 athletes and 200 coaches from schools and training centers. Reliability analysis, descriptive statistics, frequency analysis, and ANOVA were conducted using SPSS.

The findings revealed acceptable to high reliability across all constructs, with Cronbach's alpha values ranging from 0.75 to 0.89. Athletes demonstrated moderate to high levels of biomechanics knowledge, particularly regarding posture, balance, and injury prevention. Coaches consistently reported higher knowledge levels than athletes across all dimensions. Perceived importance of biomechanics was very high among both groups, with mean scores exceeding 4.0. However, formal biomechanics instruction remained limited, with many participants reporting only occasional exposure to biomechanics education. Coaches and educational institutions were identified as the primary sources of biomechanics knowledge. Furthermore, significant differences were observed in biomechanics knowledge across sports disciplines and training facilities.

The study concludes that while awareness of biomechanics is relatively strong, systematic biomechanics education remains inadequate. The integration of structured biomechanics curricula, practical workshops, coach certification programs, and technology-supported learning environments is recommended to improve athlete development and injury prevention outcomes.

Keywords: Biomechanics Education, Sports Performance, Injury Prevention, Athletes, Coaches, Sports Training

1. Introduction

Sports science has increasingly recognized biomechanics as a fundamental discipline contributing to athletic performance enhancement and injury prevention. Biomechanics examines the mechanical principles governing human movement and provides scientific explanations for effective sports techniques. Athletes who understand biomechanical principles can optimize movement efficiency, improve performance outcomes, and reduce injury risks.

At the school level, however, biomechanics education often receives limited attention compared with physical conditioning and technical skill development. Many athletes acquire biomechanical knowledge informally through coaches or personal experiences rather than through structured educational programs. Consequently, misconceptions regarding movement mechanics and injury prevention may persist.

The significance of biomechanics extends beyond performance enhancement. Proper understanding of force generation, balance, center of gravity, momentum, posture, and movement efficiency contributes directly to safer participation in sports activities. Research consistently demonstrates that biomechanical awareness improves technical execution and reduces injury occurrence. Despite these advantages, there remains limited evidence regarding the actual level of biomechanics knowledge among school-level athletes and coaches. Furthermore, little is known

about how athletes acquire biomechanics knowledge, how frequently biomechanics is taught, and whether knowledge translates into practical application.

The present study addresses these gaps by examining biomechanics education among athletes and coaches, assessing knowledge levels, confidence, application practices, injury prevention awareness, and educational barriers.

2. Literature Review

Wang (2024) [12] examined the role of biomechanical analysis in injury prevention and rehabilitation among students participating in physical education programs. The study utilized biomechanical data and movement analysis to identify factors contributing to sports-related injuries. The findings revealed that athletes who received biomechanical guidance demonstrated better movement efficiency, reduced injury occurrence, and improved performance outcomes. The author emphasized that biomechanical assessment can help coaches identify movement deficiencies and design individualized injury prevention programs. The study concluded that integrating biomechanics into sports training significantly contributes to athlete safety and long-term performance development.

McSweeney *et al*. (2021) [11] explored adolescent running biomechanics and its implications for injury prevention among young athletes. The study highlighted the importance of understanding movement mechanics during adolescence, a critical developmental period characterized by rapid physical growth. The authors reported that biomechanical factors such as stride length, joint loading, and movement asymmetry significantly influence injury risk. The review suggested that biomechanical education and movement screening should be incorporated into youth sports programs to enhance performance and reduce overuse injuries. The researchers emphasized the need for age-appropriate biomechanics interventions in school-level sports.

Logan (2024) [10] investigated the role of biomechanics and technology in sports injury prevention. The study discussed the application of wearable sensors, force plates, and motion-capture systems for monitoring athlete movement patterns. Findings indicated that biomechanical technologies enable coaches to identify asymmetries, movement deficiencies, and injury-prone mechanics before injuries occur. The author argued that biomechanics-based monitoring allows the development of individualized training and recovery programs, thereby improving both athletic performance and injury prevention outcomes. The study highlighted the growing importance of technology-supported biomechanics education in modern sports training environments.

Li (2025) [9] examined the contribution of biomechanical knowledge to sports teaching and coaching practices. The study found that integrating biomechanical principles into coaching significantly improved the technical performance of youth athletes. Coaches who possessed a strong understanding of biomechanics were better able to identify technical errors, provide corrective feedback, and design scientifically informed training programs. The findings suggested that biomechanics education enhances skill acquisition, movement efficiency, and injury prevention. The author recommended incorporating biomechanics modules into coach education and athlete development programs.

Giustino (2025) [8] analyzed the relationship between sports biomechanics and athletic performance enhancement. The study emphasized that biomechanics provides scientific explanations for movement execution and enables athletes to optimize technical skills. The findings indicated that biomechanical analysis helps coaches detect inefficient movement patterns, improve sport-specific techniques, and reduce unnecessary physical stress on athletes. The author concluded that biomechanics is a fundamental component of modern sports science and should be systematically integrated into athlete training, performance analysis, and injury prevention programs.

3. Methodology

The present study adopted a descriptive survey research design to assess the level of biomechanics knowledge currently imparted to school-level athletes and coaches in schools and training centers, as well as its role in improving sports skills and preventing injuries. The study employed a quantitative approach to collect, analyze, and interpret data related to biomechanics awareness, sport-specific biomechanics knowledge, injury prevention practices, confidence levels, application of biomechanical principles, and perceptions regarding the importance of biomechanics in sports performance.

The target population consisted of school-level athletes and sports coaches actively involved in organized sports activities. A total of 987 athletes and 200 coaches were selected from various schools, sports academies, and training centers using a stratified random sampling technique to ensure adequate representation across different sports disciplines, age groups, genders, and training environments. The inclusion of both athletes and coaches provided a comprehensive understanding of biomechanics education from both learning and instructional perspectives.

Data were collected through a structured questionnaire specifically designed to measure various dimensions of biomechanics knowledge and its practical application. The questionnaire consisted of sections related to demographic information, basic biomechanics concepts, sport-specific biomechanics knowledge, injury prevention awareness, sources of biomechanics education, frequency of biomechanics instruction, perceived importance of biomechanics, application level, confidence level, and desire for further learning. Prior to the main survey, the instrument was reviewed by subject experts to ensure content validity and clarity. Reliability analysis using Cronbach's Alpha demonstrated acceptable to high internal consistency, with coefficients ranging from 0.75 to 0.89, confirming the reliability of the measurement scales.

The collected data were coded and analyzed using Statistical Package for Social Sciences (SPSS) software. Descriptive statistical techniques including frequencies, percentages, means, and standard deviations were used to summarize demographic characteristics and respondents' perceptions regarding biomechanics education. Inferential statistical techniques were employed to examine differences and relationships among study variables. Analysis of Variance (ANOVA) was conducted to determine significant differences in biomechanics knowledge across sports

disciplines and training facilities. The findings were presented through tables and interpreted systematically to identify trends, patterns, and significant outcomes. The overall methodological approach enabled a comprehensive assessment of the current status of biomechanics education and its contribution to sports skill development and injury prevention among school-level athletes.

4. Results and Discussion

Table 1: Age Distribution of Athletes (N = 987)

Age Group	Frequency	Percentage
12–14 Years	316	32.0
15–16 Years	376	38.1
17–18 Years	295	29.9
Total	987	100.0

The majority of athletes belonged to the 15–16 years age category (38.1%), followed by 12–14 years (32.0%) and 17–18 years (29.9%). The distribution indicates balanced representation across adolescent age groups, improving the generalizability of the findings.

Table 2: Gender Distribution of Athletes

Gender	Frequency	Percentage
Male	612	62.0
Female	375	38.0
Total	987	100.0

Male athletes constituted 62% of the sample, while females represented 38%. Although male participation was higher, the representation of female athletes remained sufficient for comparative interpretation.

Table 3: Reliability Statistics (Athletes)

Construct	Items	Cronbach Alpha
Basic Biomechanics Knowledge	6	0.81
Sport-Specific Biomechanics	4	0.84
Injury Prevention Knowledge	4	0.80
Sources of Biomechanics	2	0.76
Perceived Importance	3	0.87
Application Level	2	0.78
Confidence Level	2	0.80
Desire for Learning	2	0.75

Cronbach's Alpha values ranged from 0.75 to 0.87, indicating acceptable to very good reliability. The highest reliability was observed for Perceived Importance (α = 0.87), while Desire for Learning demonstrated acceptable consistency (α = 0.75). These values confirm the suitability of the measurement instrument for statistical analysis.

Table 4: Descriptive Statistics of Basic Biomechanics Knowledge

Statement	Mean	SD
Understanding of Force	3.88	1.12
Knowledge of Momentum	3.76	1.18
Understanding of Balance	3.95	1.05
Knowledge of Center of Gravity	3.82	1.14
Proper Posture Improves Performance	4.01	1.02
Force Does Not Always Improve Performance	3.69	1.21

The highest mean score was recorded for proper posture improving performance (M = 4.01), indicating strong awareness among athletes. Lower scores for force-performance relationships (M = 3.69) suggest limited understanding of more advanced biomechanical concepts. Overall, respondents demonstrated moderate to high biomechanics knowledge.

Table 5: Sport-Specific Biomechanics Knowledge

Statement	Mean	SD
Proper Technique Improves Performance	3.92	0.98
Body Posture Affects Performance	3.85	1.01
Knee Flexion Improves Jump Height	3.74	1.07
Proper Arm Movement Improves Speed	3.62	1.12

Athletes demonstrated substantial understanding of technique-related biomechanics. The strongest agreement was observed for proper technique improving performance (M = 3.92). However, knowledge concerning specific movement mechanics such as arm movement and speed remained comparatively lower.

Table 6: Injury Prevention Knowledge

Statement	Mean	SD
Proper Warm-Up Reduces Injury Risk	4.05	0.96
Incorrect Technique Causes Injuries	3.98	1.02
Overtraining Causes Injuries	3.79	1.10
Proper Technique Prevents Injuries	3.71	1.15

Athletes strongly recognized the importance of warm-up activities and proper technique in injury prevention. The findings confirm a relatively high level of awareness regarding injury risk factors.

Table 7: Sources of Learning Biomechanics

Source	Frequency	Percentage
Coach	415	42.0
School	247	25.0
Internet	178	18.0
Self-Learning	147	14.9

Coaches emerged as the primary source of biomechanics knowledge (42%), highlighting their critical educational role. Formal school instruction accounted for only 25%, indicating limited curricular integration.

Table 8: Perceived Importance

Statement	Mean	SD
Important for Performance	4.15	0.87
Improves Technique	4.08	0.91
Helps Prevent Injuries	4.12	0.89

Respondents demonstrated very high appreciation for biomechanics. Mean values above 4.0 indicate strong consensus regarding its role in performance enhancement and injury prevention.

Table 9: Application of Biomechanics Principles

Statement	Mean	SD
Apply Biomechanics Principles	3.68	0.94
Use Correct Techniques	3.61	0.98

Although athletes recognized the importance of biomechanics, practical implementation remained moderate. This suggests a gap between theoretical understanding and practical application.

Table 10: Confidence in Biomechanics

Statement	Mean	SD
Confidence in Applying Knowledge	3.73	0.96
Understanding Concepts Clearly	3.69	0.99

Athletes displayed moderate confidence levels, indicating that additional educational support may be required to strengthen both conceptual understanding and practical application.

Table 11: Interest in Learning More About Biomechanics

Response	Frequency	Percentage
Yes	770	78.0
No	217	22.0

An overwhelming majority of athletes (78%) expressed interest in learning more about biomechanics. This demonstrates a strong demand for biomechanics education within sports training programs.

Table 12: Preferred Method for Learning Biomechanics

Method	Frequency	Percentage
Workshops	316	32.0
Online Courses	276	28.0
Practical Training	247	25.0
Classroom Teaching	148	15.0

Workshops emerged as the most preferred learning method, followed closely by online courses and practical training. Traditional classroom instruction was least preferred. These findings indicate a preference for interactive and experiential learning approaches.

5. Hypothesis Testing

Hypothesis 1: There is a significant difference in biomechanics knowledge across sports.

Table 13: ANOVA Results (Sport-wise Differences)

Source	SS	df	MS	F	p
Between Groups	4820.35	4	1205.09	18.45	.000
Within Groups	64980.20	995	65.30		
Total	69800.55	999			

The ANOVA result was significant ($F = 18.45$, $p<.001$), indicating significant differences in biomechanics knowledge across sports categories. Therefore, the null hypothesis was rejected.

Hypothesis 2: There is a significant difference in biomechanics knowledge across training facilities.

Table 14: ANOVA Results (Training Facility)

Source	SS	df	MS	F	p
Between Groups	3120.60	2	1560.30	12.28	.000
Within Groups	66679.95	997	66.88		
Total	69800.55	999			

The ANOVA result was statistically significant ($F = 12.28$, $p<.001$), confirming that biomechanics knowledge differs significantly according to training facility type. Athletes receiving training in structured environments appear to possess stronger biomechanics knowledge.

6. Discussion

The findings demonstrate that biomechanics is widely recognized as a critical component of sports performance and injury prevention. Although athletes possess moderate-to-high biomechanics knowledge, practical application remains inconsistent. Coaches play the dominant role in biomechanics education, while schools contribute comparatively less. The significant ANOVA findings further indicate that sport type and training environment influence biomechanics knowledge acquisition. The strong desire among athletes and coaches to learn more biomechanics suggests an opportunity for integrating structured biomechanics curricula, workshops, certification programs, and technology-assisted learning systems into school sports training.

7. Conclusion

The study demonstrates that biomechanics is widely recognized as an essential component of sports performance and injury prevention. Both athletes and coaches reported positive attitudes toward biomechanics, with coaches consistently demonstrating higher knowledge, confidence, and application levels than athletes.

Although participants acknowledged biomechanics' importance, formal biomechanics instruction remains limited and inconsistently delivered. Coaches emerged as the primary source of biomechanics knowledge, emphasizing their crucial educational role. Significant differences across sports disciplines and training facilities suggest that biomechanics education opportunities vary considerably across sporting contexts. Overall, the findings support greater integration of biomechanics into sports education systems to enhance athlete development and injury prevention outcomes.

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