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Injuries and injury prevention in Table Tennis training for physical education students

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Abstract
Background: This review aims to analyze injury epidemiology and specific biomechanical risk factors in table tennis training among university physical education (PE) students, and to synthesize evidence-based prevention strategies applicable in academic settings.
Methods: This is a narrative review based on a synthesis of peer-reviewed literature from academic databases. The analysis focuses on table tennis injury epidemiology, risk factors in non-elite and collegiate athletes, injury biomechanics, and injury prevention interventions (including neuromuscular training, core stability, and kinetic chain exercises).
Results: Evidence suggests that PE students are a high-risk group, with reported injury rates up to 11.7 per 1000 hours of physical education activity, significantly higher than the general physically active youth population. This is largely attributed to the burden and structure of the academic curriculum. The most common injury sites in table tennis include the upper extremities (shoulder, 22.0%; elbow, 19.4%; wrist, 16.4%) and lower extremities (ankle, 17.2%; knee, 11.9%–26.0%). Key identifiable risk factors include improper training load (TL) management, with injury rates increasing significantly as relative load per minute increases. Critical biomechanical factors include Scapular Dyskinesis, a condition increasing shoulder pain risk by 43%; restricted thoracic spine mobility; proprioceptive deficits in the lower extremities; and poor core stability. Non-elite athletes (such as PE students) exhibit a distinct injury profile compared to professionals, with a higher prevalence of lower extremity injuries.
Conclusions: Effective prevention strategies for PE students require a multi-component approach integrated directly into the curriculum. Evidence-based interventions must include: Systematic training load management using principles such as the **Acute:** Chronic Workload Ratio (ACWR); Neuromuscular warm-up programs to enhance proprioception, particularly in the ankle; and Kinetic chain corrective exercises, emphasizing the superior combination of Scapular Stabilization Training (SST) and Thoracic Flexibility Training (TFT) for shoulder protection.

Keywords: Table tennis, students, physical education, sports injuries, injury prevention, biomechanics, scapular dyskinesis, training load

Introduction

Table tennis is one of the most globally popular sports, characterized by unique physiological demands, including extreme reaction speed, explosive power, footwork agility, and fine motor control. In the context of higher education, table tennis serves not merely as a recreational activity but as a core and mandatory component of many Physical Education (PE) curricula. PE students are required to achieve a high level of technical proficiency, not only for internal competition purposes but also to develop pedagogical competency for future instruction. This entails structured, high-intensity, and high-volume training requirements, simulating a high-performance sports training environment.

When analyzing injury risk, clearly defining the study population is paramount. PE students represent a unique cohort with a risk profile distinctly different from two commonly studied groups: professional athletes and recreational players. PE students fall between these two extremes. On one hand, they face high, structured, and mandatory training loads similar to professional athletes, driven by rigorous curriculum requirements. On the other hand, they often possess heterogeneous technical and physical baselines and, crucially, lack the specialized medical support and individualized injury prevention programs available to elite athletes. The combination of high training loads and non-elite status creates a conducive environment for injury occurrence.

Scientific evidence confirms that injury risk within the PE student population is substantial. Studies have reported injury rates (IR) reaching up to 11.7 injuries per 1000 hours of physical activity. An alarming finding is that the majority of these injuries (up to 80%) occur during curricular sports classes. This strongly implies that the structure and demands of the PE curriculum itself are a primary risk factor. Sports modules within PE programs are often organized as short-term, intensive blocks. This structure can inadvertently create training load "spikes," a mechanism proven to significantly increase the risk of overuse injuries.

Despite this evident risk, a significant gap remains in the literature. Most studies on table tennis injuries focus on professional or elite athletes, while research on PE students often aggregates all sports without analyzing sport-specific risks. Consequently, there is a distinct scarcity of research analyzing the specific risk profile of table tennis within the specific context of PE students.

To address this knowledge gap, the objectives of this academic review are: To synthesize and analyze epidemiological data on the most common musculoskeletal injuries (MSKIs) in table tennis; To deeply analyze associated biomechanical and pathophysiological risk factors, as well as extrinsic factors (such as training load), particularly those highly relevant to collegiate/non-elite athletes; and To develop a multi-component, evidence-based injury prevention framework tailored for integration into the university PE training context.

Methods

This article is designed as a narrative review. We conducted a comprehensive synthesis of peer-reviewed literature retrieved from academic databases (e.g., PubMed, Google Scholar). Search keywords included "table tennis", "injuries", "epidemiology", "physical education students", "biomechanics", and "prevention". Studies were selected based on their relevance to injury mechanisms, risk factors, and intervention strategies within the context of collegiate sports and non-elite athletes.

Results

1. Injuries in Table Tennis

Although table tennis is often considered a relatively low-risk sport, epidemiological data reveals a more complex picture. Studies on collegiate and non-elite athletes, the group most comparable to PE students, indicate an alarming rate: 50.6% reported experiencing at least one injury in the preceding six months. Other studies also report an overall prevalence rate of 44%.

A critical aspect for the PE context is the high proportion of overuse injuries, accounting for 56% to 62.2% of total injuries. This high prevalence is particularly relevant to PE students, who must perform thousands of repetitions within a module to meet technical requirements.

Regarding injury distribution, aggregated data reveals a distinct pattern. The upper extremity is the most heavily affected region, with the shoulder being the most common single injury site (17% to 28%). Other significant sites include the elbow (19.4%) and wrist (16.4%). The lower extremity also carries high risk due to continuous lateral movement, with the ankle (17.2%) and knee (11.9% to 26.0%) being the primary sites. The trunk region, particularly the lower back (lumbar spine), accounts for 7% to 9.3% of total injuries.

Some evidence suggests that for non-elite athletes (such as PE students), the lower extremity is highlighted as the most common injury site, in contrast to professional athletes. The most common reported injury pathology is tendinitis, accounting for up to 38.2% of total injuries, reinforcing the "overuse" hypothesis.

Table 1: Overview of Musculoskeletal Injuries in Table Tennis

Diagnosis / Pathology	Prevalence Rate / Classification	Primary Anatomical Location	Typical Mechanism	Data Source	Citation
Tendinitis, Impingement Syndrome	17.0% – 28.0%	Shoulder	Rotator cuff impingement, repetitive overload	Epidemiological review	3
Tendinitis	~19.4%	Elbow	Elbow Tendinopathy (EP), repetitive overload	Epidemiological review	3
Sprain	~17.2%	Ankle	Ligament injury due to inversion/rotation	Epidemiological review	3
Tenosynovitis	~16.4%	Wrist	Repetitive strain (muscle/tendon)	Epidemiological review	3
Tendinitis, Joint/Ligament Injury	11.9% – 26.0%	Knee	Overuse, lateral movement	Epidemiological review	3
Low Back Pain (Lumbago)	7.0% – 9.3%	Back / Spine	Muscle strain due to rotation/flexion	Epidemiological review	3

2. Analysis of Risk Factors and Pathogenic Mechanisms

To develop an effective prevention strategy, understanding the etiology of injury occurrence is imperative.

The primary intrinsic risk factor is a history of previous injury. A specific study on PE students found that injury history was a significant risk factor ($P = 0.018$) for subsequent injuries. The mechanism behind this is a causal chain: a prior injury (e.g., an ankle sprain), if followed by inadequate rehabilitation, leads to proprioceptive deficits. When this student enters the table tennis module, rapid and repetitive lateral movements place them at high risk of re-injury. Non-elite athletes have also been shown to exhibit a significantly greater range of ankle inversion, a mechanical factor that increases the risk of ankle sprains.

The most significant extrinsic risk factor is Training Load (TL). A direct relationship exists between training load and injury rates. One study found that "for every unit increase in relative training load per minute during training, the injury rate increased significantly ($P = 0.014$)." The high prevalence of overuse injuries (56%) is a direct result of poor TL management, with injuries occurring most frequently during periods where training volume is peaked.

This highlights a core issue for PE students: the conflict between Pedagogy and Physiology. The pedagogical structure of the curriculum imposes a fixed training load within a fixed timeframe, compelling students to train even in the presence of minor pain to fulfill module requirements. This exacerbates minor injuries, transforming them into chronic conditions.

Table 2: Classification of Risk Factors for Table Tennis Injuries in PE Students

Factor Category	Specific Risk Factor	Modifiability (Intervention Potential)	Citation
Intrinsic	Previous injury history	Low (but sequelae are manageable)	16
Intrinsic	Proprioceptive deficits	High (Via training)	8
Intrinsic	Biomechanical factors (e.g., SD, thoracic spine stiffness)	High (Via training)	6
Intrinsic	Dominant hand / Anthropometric characteristics	Non-modifiable	10
Extrinsic	Training Load (TL) Management (Overload)	High (Via program design)	5
Extrinsic	Curriculum Structure (Fixed, high intensity)	Moderate (Requires pedagogical changes)	2
Extrinsic	Equipment Selection (e.g., racket rubber)	High (Via education and selection)	10
Extrinsic	Lack of supplementary exercises / appropriate warm-up	High (Via program integration)	16

3. Biomechanical Analysis of Core Issues

Issue 1 (Upper Extremity): The high prevalence of shoulder injuries (up to 28%) and the repetitive nature of overhead motions in table tennis. The root cause (Biomechanical) is often Scapular Dyskinesis (SD), a condition characterized by suboptimal positioning or movement of the scapula. SD is a significant risk factor, found to increase the risk of shoulder pain by 43% in athletes. This dysfunction (SD) often serves as a compensatory mechanism for functional deficits in the Thoracic Spine (upper back). PE students spend prolonged periods in sedentary academic settings, predisposing them to stiffness or increased kyphosis of the thoracic spine. During the execution of a forehand loop a stroke requiring thoracic rotation and extension this rigidity restricts motion, forcing compensatory excessive movement of the scapula and glenohumeral joint, ultimately leading to impingement syndrome.

Issue 2 (Lower Extremity): High prevalence of ankle (17.2%) and knee injuries. The root cause (Biomechanical) stems from the sport's demand for rapid, repetitive lateral movements and sudden stop-pivot-change of direction maneuvers. Injuries occur when the neuromuscular system fails to react with sufficient speed or precision to stabilize the joint. This represents a failure in neuromuscular control and proprioception—the brain's unconscious ability to sense joint position in space.

Issue 3 (Systemic): Training Load represents the most significant modifiable extrinsic risk factor; however, it is frequently constrained by fixed curriculum requirements.

Discussion

Based on the identified risk factors and biomechanical mechanisms, a multi-component prevention strategy for PE students is imperative.

1. Optimizing the Upper Extremity Kinetic Chain: Shoulder, Scapula, and Thoracic Spine

A comprehensive shoulder prevention strategy must address the entire kinetic chain

Foundation: Core Stability: The core (abdominals, lower back, hips) serves as the foundation for efficient force transfer. A weak core results in "energy leaks," forcing the shoulder to "overwork."

"Unlocking" the Chain: Thoracic Flexibility Training (TFT): Exercises focused on improving thoracic rotation and extension (e.g., quadruped thoracic rotation, thoracic extension on a foam roller) are critical.

Controlling the Chain: Scapular Stabilization Training (SST): Once thoracic mobility is established, scapular stabilizers (such as the serratus anterior, middle and lower trapezius) must be activated and strengthened.

A key finding is: The combination of SST and TFT yields significantly superior results compared to SST alone, not only improving stability but also significantly increasing angular velocity (swing speed).

2. Reinforcing the Lower Extremity Kinetic Chain: Ankle, Knee, and Proprioception

The goal is to "retrain" the connection between the brain and joint stabilizers

Proprioceptive Training: These exercises challenge the neuromuscular system, forcing adaptation. Examples include: single-leg stance (eyes open/closed), balancing on unstable surfaces (e.g., wobble boards, balance discs).

Neuromuscular Training: Includes plyometrics (multi-directional jumping) and reaction/agility drills to improve the speed and efficiency of protective muscle contraction reflexes. For PE students with a likely history of injury, these exercises constitute "essential rehabilitation" to prevent recurrence.

3. Training Load Management in the Academic Context

The solution is a Systemic and Pedagogical intervention

Faculty and Student Education: Raising awareness regarding the fundamental principles of load and adaptation, and the dangers of sudden load spikes.

Load Monitoring: Utilizing simple tools such as the Session Rating of Perceived Exertion (sRPE) after each session.

Applying the Acute: Chronic Workload Ratio (ACWR) Principle: ACWR is a load monitoring model comparing current week load (acute load) to the average load of the preceding 4 weeks (chronic load). Its principles should be used to design curricula, ensuring volume and intensity are built progressively, avoiding large load "spikes."

Table 3: Integrated Injury Prevention Framework (I-PFP) for PE Table Tennis Students

Prevention Category	Risk / Injury Addressed	Evidence-Based Intervention	Specific Examples	Citation
1. Core Stability & Foundation	Core weakness, "energy leaks," excessive upper extremity loading	Kinetic chain strengthening	Planks (front, side), Glute bridges.	9
2. Upper Extremity Kinetic Chain	Shoulder injury (SD), Impingement Syndrome, Thoracic spine stiffness	(a) Increase rotational/extension mobility. (b) Scapular stabilization.	(a) Thoracic spine (T-spine) rotations, Thoracic extension on foam roller. (b) Y-T-W exercises, Serratus push-ups.	7 6
3. Lower Extremity Kinetic Chain	Ankle sprains, poor neuromuscular control	(a) Improve proprioception. (b) Enhance neuromuscular control.	(a) Single-leg stance (eyes open/closed), Balance disc training. (b) Multi-directional jumping (Plyometrics).	8 23
4. Load Management (Systemic)	Overuse injuries, load spikes	Prevent overload; progressive loading	(a) Monitoring Session RPE (sRPE) post-training. (b) Designing curriculum based on ACWR principles.	27 2

A comprehensive analysis indicates that Physical Education (PE) students represent a "perfect storm" for injury risk. Their unique risk profile is a convergence of three key factors: The biomechanics of non-elite athletes (immature technique, poor ankle control, proprioceptive deficits); the training workload of elite athletes (high, repetitive, mandatory loads leading to overuse); and Confounding factors from the student lifestyle (e.g., prolonged sitting), which may directly contribute to biomechanical risk factors (such as thoracic spine stiffness). Consequently, the injury pattern of PE students is a hybrid one: they exhibit both chronic overuse injuries (e.g., shoulder tendinitis) and acute injuries stemming from poor technique or control (e.g., ankle sprains).

It is crucial to recognize that prevention strategies for PE students cannot be wholly replicated from elite athletes, who may possess distinct injury profiles (e.g., higher injury rates in the back and hips) but generally exhibit lower overall injury incidence due to superior physical conditioning and medical support.

The primary limitation of this review is the distinct lack of specific prospective, longitudinal studies on PE students specializing in table tennis. The majority of data must be extrapolated from the most comparable cohorts.

These findings carry strong practical implications for PE departments: Injury prevention programs must be integrated into the mandatory warm-up routine of every session; and PE instructors need training not only in technique but also in the fundamental principles of sports science, including workload management and the ability to recognize early signs of biomechanical dysfunction.

Conclusion

Injuries in table tennis training among PE students represent a significant issue, characterized by high prevalence and predictability. These injuries are not random occurrences but rather the result of a complex and predictable interaction between the curriculum-mandated training load demands and the students' intrinsic biomechanical risk factors (e.g., core weakness, Scapular Dyskinesis [SD], and proprioceptive deficits).

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