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Risk Factors Among the Physical Education Students in Changchun: A Means for Evaluation Framework

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A R T I C L E I N F O

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A B S T R A C T

This study developed a weighted evaluation framework for sports-participation risks among physical education students in Changchun. A sequential mixed-methods design combined a descriptive questionnaire completed by 30 students enrolled in physical education-related programs with expert interviews, two Delphi rounds, and the Analytic Hierarchy Process (AHP) involving 12 experts. Student results identified inadequate warm-up, academic stress, extreme weather, equipment and surface conditions, and gaps in screening and medical support as salient concerns. The final expert-validated framework comprised 32 indicators across five domains. Human factors received the highest criterion weight (0.4251), followed by environmental (0.2532), management and organizational (0.1505), sports activity (0.0993), and social and psychological factors (0.0719). All AHP judgment matrices met CR < 0.10. The combined student and expert evidence provides a structured basis for risk screening, safety education, facility management, emergency preparedness, and priority-based resource allocation.

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INTRODUCTION

Physical education is an important component of university education because it supports students' physical health, psychosocial development, and lifelong participation in physical activity. At the same time, sport and exercise involve injury and illness risks arising from interactions among participant characteristics, activity demands, environmental conditions, and institutional practices. Effective prevention therefore requires systematic risk identification as well as appropriate management and response measures (Göpfert et al., 2018). Previous school-sport research has emphasized general risk-management processes and response strategies, while locally applicable systems for identifying and prioritizing specific risks remain comparatively underdeveloped. This study focuses on students enrolled in physical education-related programs in Changchun and integrates literature review, expert interviews, Delphi consultation, and the Analytic Hierarchy Process to construct a weighted sports-risk evaluation framework.

THEORETICAL REVIEW

Sports participation supports physical and psychosocial development, but risk arises from interactions among student characteristics, activity demands, facilities, environmental conditions, and institutional practices (Mitchell, 2018). Research consistently identifies insufficient physical fitness, previous injury, inadequate warm-up, poor technique, fatigue, and limited safety awareness as important individual-level risks (Cui & Yan, 2022; Ge et al., 2020; Li et al., 2023; Li & Yuan, 2021; Sun, 2020). Injury patterns also vary by sport: collision, speed, aerial movement, and technical complexity increase exposure, while strains, sprains, and traumatic injuries remain common concerns in school settings (Greier et al., 2018; Li, 2019; Rauh et al., 2021; Yan & Tian, 2020).

Environmental and organizational conditions can either amplify or control these risks. Weather, air quality, venue layout, surface condition, lighting, protective barriers, and equipment maintenance have repeatedly been identified as core environmental dimensions (Fan, 2023; Jiao & Wang, 2019; Liang & Liang, 2022; Niu, 2023). Management studies emphasize regulations, supervision, safety education, medical support, emergency planning, and integrated risk-control mechanisms (Chang & Wang, 2022; Chen et al., 2023; Lu & Wang, 2020; Xu et al., 2023; Zhou, 2021). Broader models further recognize that risk is embedded in the interaction of people, activities, time, and institutional context (Liang et al., 2020).

Sport-specific research additionally highlights unpredictable outdoor conditions, collision and flying-object hazards, drowning, sudden medical events, and injuries associated with specialized or high-intensity activities (Wu, 2019; Xiao, 2021; Zhao, 2022). Nutrition and eating-related concerns may also affect safety and performance, particularly in aesthetic and weight-sensitive sports (Francisco et al., 2012; Martínez-Rodríguez et al., 2018). Although this literature identifies many relevant factors, existing classifications vary considerably, often emphasize single disciplines, and rarely provide a locally validated hierarchy with explicit weights for university decision-making.

Theoretical and Conceptual Framework

The framework integrates three complementary theories. The Health Belief Model explains how perceived susceptibility, severity, benefits, barriers, and self-efficacy shape preventive behavior (Rosenstock et al., 1988). Self-Determination Theory clarifies how autonomy, competence, and relatedness influence safe participation and adherence to guidance (Ryan & Deci, 2000). Ecological Systems Theory locates student behavior within interacting interpersonal, institutional, community, and policy environments (Bronfenbrenner, 1979). Together, these perspectives support five domains: human, environmental, management and organizational, sports activity, and social and psychological factors.

Significance of the Study

The study contributes a transparent expert-validated structure for identifying and prioritizing sports-participation risks among physical education students in Changchun. The weighted framework can guide safety education, health screening, facility maintenance, emergency preparedness, staff training, and resource allocation while providing a reproducible basis for subsequent field validation.

Objectives of the Study

1. To determine the risk factors for sports participation among physical education students in Changchun.
2. To establish the Changchun College Students' Sports Risk Evaluation Index System.
3. To develop evidence-based strategies for reducing the risks of sports participation among physical education students in Changchun.

METHODOLOGY

This study used a sequential mixed-methods design integrating a descriptive student questionnaire with three framework-development phases. The student questionnaire documented perceived risks, risk awareness, a risk-factor checklist, and preferred risk-reduction strategies. Phase I used literature review, expert interviews, and checklist review to identify risk factors; Phase II used two Delphi rounds to validate the evaluation index system; and Phase III used the Analytic Hierarchy Process to assign weights and support strategy development. Student questionnaire findings were first analyzed descriptively and were subsequently triangulated with the expert-derived Delphi and AHP results.

Student Questionnaire

Using stratified sampling across academic year, gender, and physical education-related program, a structured English-language questionnaire was completed by 30 students in Changchun. Eligibility followed the informed-consent criteria: respondents were formally enrolled in physical education-related programs, regularly attended physical education classes, and had no

diagnosed condition preventing participation in regular physical education. The instrument contained physical, psychological, environmental and facility, institutional and organizational, risk-awareness, checklist, and risk-reduction strategy sections. Five-point items were summarized using means and sample standard deviations; checklist responses were summarized using percentages.

Phase I: Risk Factor Identification

A structured review covered 86 scholarly and institutional sources published from 2017 to 2024 and retrieved primarily from CNKI, Wanfang Data, and the China Journal Database. Search terms addressed college students, physical education, sports risk, injury, health, environment, and risk cognition. Semi-structured interviews were then conducted with 12 purposively selected experts in physical education, sports medicine, sports health care, clinical medicine, and risk management. Literature and interview findings were coded thematically, yielding 38 candidate indicators. Expert checklist review assessed clarity, relevance, comprehensiveness, and contextual suitability, resulting in 36 indicators across five domains.

Phase II: Delphi Validation

The same 12 experts completed two rounds of anonymous structured questionnaires using a five-point importance scale (1 = not important, 5 = extremely important). After Round 1, indicators were retained, revised, merged, added, or deleted based on mean ratings, standard deviations, coefficients of variation, qualitative comments, and panel judgment. Round 2 re-evaluated the refined set. Consensus was assessed using Kendall's coefficient of concordance corrected for tied ranks; expert credibility was assessed using the judgment-basis coefficient (Ca), familiarity coefficient (Cs), and authority coefficient Cr = (Ca + Cs) / 2. The procedure followed established Delphi reporting principles (Jünger et al., 2017).

Phase III: AHP Weight Assignment

Experts completed pairwise comparisons using Saaty's nine-point scale (Saaty, 1980). Geometric means aggregated judgments into a three-level hierarchy consisting of the overall goal, five criterion domains, and 32 indicators. Principal eigenvectors produced local and global weights. Maximum eigenvalues, consistency indices, and consistency ratios were calculated for every matrix; CR < 0.10 indicated acceptable consistency.

Population, Data Analysis, and Ethics

The study involved two participant groups: 30 students enrolled in physical education-related programs and a 12-member expert panel. The student respondents represented different academic years, genders, programs, and sports activities. Student questionnaire data were summarized using frequencies, percentages, means, and sample standard deviations. Experts were purposively selected and had at least five years of relevant professional experience. Interview data underwent thematic analysis; Delphi data were summarized using M, SD, CV, Ca, Cs, Cr, Kendall's W, chi-square, degrees of freedom, and p values; and

AHP data were analyzed using local weights, global weights, lambda-max, CI, and CR. Ethical approval was granted by the University of Baguio in April 2025. All participants provided written informed consent. Student and expert identifiers were replaced with codes S001-S030 and E01-E12, respectively.

Data analysis followed four sequential steps: questionnaire screening and descriptive analysis, thematic coding of qualitative evidence, Delphi consensus analysis, and AHP weight calculation and consistency testing. All 30 returned questionnaires were screened for completeness before analysis, and no questionnaire was excluded. Frequency and percentage distributions were used to summarize demographic characteristics and checklist responses. Means and sample standard deviations were calculated for five-point Likert-scale items. Mean scores were interpreted using the following intervals: 4.21–5.00 as Very High, 3.41–4.20 as High, 2.61–3.40 as Moderate, and 1.81–2.60 as Low. Positively worded institutional and facility items were interpreted as perceived adequacy rather than direct risk severity; consequently, a high mean on such items indicated a favorable perception of institutional provision rather than elevated risk.

The interview transcripts and literature-derived indicators were coded thematically by the researcher. Similar codes were grouped, overlapping indicators were merged, and contextually irrelevant items were removed through expert checklist review, reducing the initial pool from 38 to 36 candidate indicators. Delphi ratings were summarized using the mean, standard deviation, and coefficient of variation for each indicator. Indicators were generally considered for deletion when $M < 3.50$ or $CV > 0.25$; however, final retention decisions also incorporated qualitative expert comments and practical relevance, which is why Round 2 indicators A8 (history of previous injuries) and C5 (medical support services) were retained despite crossing the statistical threshold. Kendall's coefficient of concordance, corrected for tied ranks, was used to assess inter-expert agreement across the panel, with statistical significance evaluated at $p < 0.05$. Expert authority was calculated as $Cr = (Ca + Cs) / 2$, where Ca reflects the judgment basis and Cs reflects familiarity with the indicator domain.

For AHP analysis, the 12 experts completed pairwise comparison matrices using Saaty's nine-point scale. Individual judgments were aggregated using the geometric mean to construct group matrices, a procedure commonly used in group decision-making contexts. Principal eigenvectors were normalized to derive local weights for each indicator within its criterion domain, and global weights were calculated by multiplying each local indicator weight by its corresponding criterion weight. Matrix consistency was evaluated using the consistency index, $CI = (\lambda max - n) / (n - 1)$, and the consistency ratio, $CR = CI / RI$, where RI represents the random index corresponding to a matrix of order n (Saaty, 1980). A CR value below 0.10 was considered acceptable. Matrices exceeding this threshold would have been returned to the experts for reconsideration; however, all matrices in the present study met the required consistency criterion, with a criterion-level CR of 0.0164 and all indicator-level CR values below 0.10.

Data were entered and checked in Microsoft Excel. Descriptive statistics, frequency distributions, and Kendall's W were computed using Python (SciPy and NumPy libraries). AHP judgment matrices, eigenvector calculations, and consistency tests were performed in Microsoft Excel. The significance level for all statistical tests was set at $\alpha = 0.05$.

RESULTS AND DISCUSSION

The findings are organized to address Objectives 1, 2, and 3. The student-questionnaire tables (Tables 1-7) are presented first, followed by the Delphi and AHP results.

Profile of the Student Respondents

The student sample comprised 30 respondents: 17 women (56.7%) and 13 men (43.3%). Ages ranged from 18 to 24 years (M = 20.37, SD = 1.83). Eleven respondents were freshmen (36.7%), nine were sophomores (30.0%), four were juniors (13.3%), two were seniors (6.7%), and four were graduate students (13.3%).

Fourteen respondents studied Physical Education (46.7%), seven Sports Training (23.3%), six Recreation Sports (20.0%), and three Health Education (10.0%). Weekly sports participation ranged from 1.7 to 11.7 hours (M = 5.05, SD = 2.12). Swimming was the most frequently reported activity (n = 6), followed by basketball, martial arts, table tennis, track and field, and volleyball (each n = 4), badminton (n = 3), and football (n = 1).

Objective 1: Risk Factors Associated With Sports Participation

Objective 1 examined students' perceived physical, psychological, environmental and facility, and institutional and organizational risk factors.

Table 1. The physical risk factors associated with sports (N = 30)

Indicators	Mean	SD	Interpretation
1. I regularly experience physical fatigue or exhaustion during sports.	3.77	0.63	High
2. I have a history of recurring injuries (e.g., sprains, fractures, muscle tears) that compromise my safety during sports.	3.47	0.63	High
3. I consider my current physical fitness level (e.g., cardiovascular endurance, strength, flexibility) adequate for the sports I engage in.	3.63	0.81	High
4. I frequently participate in sports without an adequate warm-up or cool-down routine.	3.93	0.58	High
5. I have been medically advised to restrict my sports activities due to a physical health condition.	2.53	0.90	Low
6. I am aware of my body's physical limits during intense training.	3.73	0.45	High
7. Excessive physical exertion is a common issue in my institution.	3.77	0.63	High
8. Body composition (e.g., body mass index, muscle-to-fat ratio) significantly influences the level of risk I face during sports.	3.33	0.80	Moderate

Note. For positively worded items, the interpretation indicates the level of agreement with the statement rather than the severity of risk. Higher mean scores on positively worded items therefore reflect more favorable self-assessments or perceptions.

In the physical domain, inadequate warm-up received the highest mean (M = 3.93, SD = 0.58). Physical fatigue and excessive exertion both reached M = 3.77, while awareness of physical limits was also high (M = 3.73). Medical restriction was rated low (M = 2.53), indicating that the more immediate concerns involved routine preparation, fatigue, and exertion rather than formally diagnosed restrictions.

Table 2. The psychological risk factors associated with sports (N = 30)

Indicators	Mean	SD	Interpretation
1. Competition-related anxiety compromises my performance during sports activities.	3.67	0.76	High
2. I feel pressured to perform in sports when I am aware that I lack readiness for the activity.	3.63	0.76	High
3. I lose emotional control when experiencing setbacks or injuries.	3.30	0.60	Moderate
4. Fear of failure drives me to take risky sports activities.	3.37	0.56	Moderate
5. Low psychological readiness (motivation, confidence) poses a hazard to my safety.	3.53	0.57	High
6. Academic stress degrades my situational concentration during sports participation.	3.80	0.71	High
7. Psychological warning signs compel me to cease or reduce physical activity.	3.37	0.96	Moderate
8. Emotional distress influences my ability to make safe decisions during sports activities.	3.50	0.82	High

Academic stress degrading concentration was the leading psychological concern (M = 3.80, SD = 0.71), followed by competition-related anxiety (M = 3.67) and pressure to perform when unwell (M = 3.63). These results support attention to psychological readiness and decision-making under pressure in addition to physical safeguards.

Table 3. The environmental and facility risk factors associated with sports (N = 30)

Indicators	Mean	SD	Interpretation
1. The sports facilities available at my institution are well-maintained and safe for use.	3.17	0.79	Moderate
2. Extreme weather conditions in Changchun (e.g., severe winter cold, high summer temperatures) limit the safety of sports activities.	4.20	0.48	Very High
3. Inadequate sports equipment increases the risk of injury during sports activities.	3.60	0.62	High

Indicators	Mean	SD	Interpretation
4. Poorly maintained sports equipment increases the risk of injury during sports activities.	3.50	0.63	High
5. Sports venues at my institution are sufficiently spacious and appropriately designed to accommodate student activity without overcrowding.	3.00	0.79	Moderate
6. The physical conditions (lighting and ventilation) in indoor sports are conducive to training.	3.40	0.77	Moderate
7. The scheduling of sports activities (e.g., timing, duration, intensity) poses a risk of injury.	3.50	0.63	High
8. Poor field or court surface conditions (e.g., uneven ground, slippery floors) pose a risk to student athletes.	3.67	0.71	High

Note. Positively worded facility items reflect perceived adequacy rather than direct risk severity. Higher scores on these items indicate more favorable perceptions of facility conditions.

Extreme weather in Changchun received the highest environmental rating (M = 4.20, SD = 0.48), followed by poor field or court surfaces (M = 3.67) and inadequate equipment (M = 3.60). Positively worded facility-maintenance and venue-space items should be read as perceptions of adequacy rather than as direct measures of risk severity; their moderate means indicate room for improvement.

Table 4. The institutional and organizational risk factors associated with sports (N = 30)

Indicators	Mean	SD	Interpretation
1. My institution has a clearly defined policy for managing sports-related injuries and emergencies.	3.27	0.74	Moderate
2. Physical education instructors at my institution are adequately trained in sports injury prevention and first-aid response.	3.63	0.56	High
3. My institution conducts regular pre-participation physical assessments for students enrolled in PE programs.	3.20	0.71	Moderate
4. Supervision during sports training sessions at my institution is sufficient to ensure safety.	3.50	0.68	High
5. My institution provides adequate sports risk education to all participants in sports activities.	3.40	0.56	Moderate
6. Medical support personnel are readily accessible at my institution during and after sports activities.	3.13	0.63	Moderate
7. My institution systematically updates its sports safety policies in response to incidents or emerging evidence.	3.23	0.63	Moderate
8. Course design in PE programs is appropriately calibrated to match students' physical capabilities and minimize overexertion.	3.43	0.90	High

Note. Positively worded institutional items reflect perceived adequacy of institutional provision rather than the level of institutional risk.

Students rated instructor training (M = 3.63), supervision (M = 3.50), and course calibration (M = 3.43) relatively positively. Lower ratings for medical support access (M = 3.13), pre-participation screening (M = 3.20), and systematic policy updating (M = 3.23) identify organizational areas requiring attention.

Objective 2: Sports Risk Evaluation Index System

Objective 2 was addressed through students' risk-awareness ratings and the structured checklist, followed by expert refinement and weighting in the Delphi and AHP sections.

Table 5. Sports risk awareness among college students in Changchun (N = 30)

Statement	Mean	SD	Interpretation
1. I have a thorough understanding of the risks associated with the specific sports I regularly participate in.	3.63	0.85	High
2. I actively seek information about sports safety and injury prevention strategies.	3.50	0.57	High
3. I believe that sports injuries are largely preventable if appropriate precautions are taken.	3.93	0.52	High
4. I consistently follow the safety rules and guidelines established for the sports activities I engage in.	3.77	0.68	High
5. I promptly report sports-related injuries or health concerns to a qualified instructor or medical professional.	3.73	0.69	High
6. I am aware of the correct procedures for responding to sports-related emergencies (e.g., acute injuries, cardiac events).	3.50	0.51	High
7. I consider risk management an essential component of sports participation, not merely an institutional obligation.	4.13	0.78	High

Risk awareness was consistently high. Students most strongly endorsed risk management as an essential component of sports participation (M = 4.13, SD = 0.78) and the preventability of injuries when precautions are taken (M = 3.93, SD = 0.52). Reporting, rule-following, emergency awareness, and active information seeking were also rated high, providing a behavioral basis for the evaluation system.

Table 6. Sports Risk Factor Checklist (N = 30)

Risk Factor	Yes	No	Unsure
1. Absence of a systematic pre-participation health screening protocol	53%	20%	27%
2. Insufficient warm-up and cool-down practices before and after training	60%	13%	27%
3. Overloaded or poorly periodized training schedules	50%	27%	23%
4. Inadequate or defective sports protective equipment (e.g., helmets, knee pads)	47%	30%	23%
5. Participation in sports activities while injured or unwell	40%	30%	30%

Risk Factor	Yes	No	Unsure
6. Chronic fatigue or insufficient recovery time between training sessions	53%	27%	20%
7. Exposure to extreme or unpredictable weather conditions	53%	20%	27%
8. Lack of qualified first-aid or emergency response support at sports venues	43%	30%	27%
9. Use of hazardous or substandard sports facilities or surfaces	20%	37%	43%
10. Insufficient instructor or supervisor oversight during high-risk activities	37%	37%	27%
11. Inadequate hydration and nutritional support during training	43%	40%	17%
12. Psychological pressure from coaches, instructors, or peers to train despite discomfort	33%	43%	23%
13. Absence of clear institutional communication regarding sports safety guidelines	37%	20%	43%
14. Participation in high-intensity activities without adequate physical conditioning	57%	13%	30%
15. Failure to report minor injuries, which may lead to aggravation over time	57%	20%	23%

The checklist most frequently identified insufficient warm-up or cool-down practices (60% Yes), high-intensity activity without adequate preparation (57%), failure to report minor injuries (57%), absence of health screening (53%), chronic fatigue or insufficient recovery (53%), and exposure to extreme weather (53%). These student-identified concerns overlap with the human, environmental, and organizational domains later retained by the expert panel.

Objective 3: Evidence-Based Strategies for Reducing Sports Risk

Table 7. Evidence-based strategies for reducing the risk of sports participation (N = 30)

Risk Reduction Strategy	Mean	SD	Interpretation
1. Mandatory pre-participation physical health screening for all college PE students	4.27	0.45	Very High
2. Regular sports safety training and education programs for students and instructors	4.17	0.59	High
3. Systematic inspection and maintenance of sports facilities and equipment	4.07	0.64	High
4. Development and enforcement of institutional sports risk management policies	4.00	0.59	High
5. Integration of sports injury prevention modules into the PE curriculum	4.23	0.50	Very High
6. Provision of on-site medical or first-aid personnel at sports training venues	4.27	0.58	Very High
7. Implementation of evidence-based training load monitoring systems	3.87	0.68	High

Risk Reduction Strategy	Mean	SD	Interpretation
8. Establishment of a confidential sports injury reporting and tracking system	4.00	0.64	High
9. Peer-education initiatives promoting sports safety awareness among students	3.80	0.55	High
10. Adaptation of sports activities to accommodate individual physical limitations	4.10	0.61	High

Students gave very high ratings to mandatory pre-participation health screening and on-site medical or first-aid personnel (both M = 4.27), followed by integrating injury prevention into the physical education curriculum (M = 4.23). All remaining strategies were rated high, supporting a combined approach involving education, facility inspection, policy enforcement, training-load monitoring, confidential injury reporting, peer education, and activity adaptation.

Note. For five-point tables: 4.21-5.00 = Very High; 3.41-4.20 = High; 2.61-3.40 = Moderate; 1.81-2.60 = Low. Checklist percentages are based on N = 30.

Delphi and AHP Results

The student findings were followed by the expert-based framework-development results. Detailed expert-level scores and complete judgment matrices are retained in the study records and are available from the author upon reasonable request.

Phase I: Identification of Sports Risk Factors

The review of 86 sources and interviews with 12 experts generated 38 candidate indicators. Checklist review removed two insufficiently relevant items and organized the remaining 36 indicators into Human (10), Environmental (8), Management and Organizational (7), Sports Activity (6), and Social and Psychological (5) domains. The panel comprised seven men and five women, aged 38-55 years (M = 46.4), with 9-28 years of experience (M = 19.3).

Phase II: Delphi Validation

All 12 experts completed both Delphi rounds. Round 1 removed four low-consensus indicators, merged two overlapping indicators, and added psychological readiness, producing 32 indicators for Round 2. The revised indicators were renumbered sequentially within each domain. Table 8 summarizes the revisions.

Table 8. Round 1 Indicator Revisions and Round 2 Recoding

Code reference	Indicator	Decision
R1 A3 + A9	Lack of safety knowledge + low self-protection awareness	Merged as safety awareness and self-protection capability

R1 A8	Insufficient sleep and recovery	Deleted: M = 2.92, CV = 0.34
R1 B8	Inadequate ventilation	Deleted: M = 3.33, CV = 0.41
R1 C5	Poorly designed PE curriculum	Deleted: M = 3.00, CV = 0.38
R1 D6	Specialized equipment requirements	Deleted: M = 3.08, CV = 0.26
R2 A9	Psychological readiness	Added following expert recommendation

Note. R1 = Round 1; R2 = Round 2. Deletion threshold: M < 3.50 or CV > 0.25, with panel judgment used for final decisions. After refinement, codes were reassigned sequentially; R1 A8 and R1 C5 are not the same indicators as Round 2 A8 and C5.

In Round 2, expert authority was high (Ca = 0.900, Cs = 0.850, Cr = 0.875). Kendall's W increased from 0.4044 in Round 1 (chi-square = 169.85, df = 35, $p < 0.001$) to 0.4808 in Round 2 (chi-square = 178.84, df = 31, $p < 0.001$). The Round 2 indicators A8 (history of previous injuries) and C5 (medical support services) were retained by explicit panel judgment despite crossing the screening threshold because of their practical importance.

Table 9. Round 2 Expert Questionnaire Ratings: Human Factors (N = 12)

Code	Indicator	M	SD	CV	Interpretation
A1	Insufficient physical fitness	4.17	0.58	0.14	Very important
A2	Pre-existing chronic conditions	4.58	0.51	0.11	Extremely important
A3	Safety awareness & self-protection	4.75	0.45	0.10	Extremely important
A4	Inadequate warm-up	3.92	0.51	0.13	Very important
A5	Poor exercise technique	4.42	0.67	0.15	Extremely important
A6	Fatigue and overtraining	3.83	0.58	0.15	Very important
A7	Poor nutrition & hydration	4.75	0.45	0.10	Extremely important
A8	History of previous injuries	3.08	0.79	0.26	Moderate; retained
A9	Psychological readiness	4.00	0.60	0.15	Very important

Table 10. Round 2 Expert Questionnaire Ratings: Environmental Factors (N = 12)

Code	Indicator	M	SD	CV	Interpretation
B1	Extreme weather conditions	4.42	0.51	0.12	Extremely important
B2	Air quality and pollution	4.17	0.39	0.09	Very important
B3	Venue size and layout	4.33	0.65	0.15	Extremely important
B4	Field and court surface	4.00	0.43	0.11	Very important
B5	Equipment condition & maintenance	4.33	0.49	0.11	Extremely important
B6	Protective barriers & padding	4.42	0.51	0.12	Extremely important
B7	Lighting adequacy	3.92	0.67	0.17	Very important

Table 11. Round 2 Expert Questionnaire Ratings: Management and Organizational Factors (N = 12)

Code	Indicator	M	SD	CV	Interpretation
C1	Sports safety regulations	4.08	0.29	0.07	Very important
C2	Teacher supervision quality	4.50	0.52	0.12	Extremely important
C3	Emergency response plans	3.83	0.39	0.10	Very important
C4	Safety education programs	3.75	0.62	0.17	Very important
C5	Medical support services	3.08	1.00	0.32	Moderate; retained
C6	Institutional risk management	4.17	0.58	0.14	Very important

Table 12. Round 2 Expert Questionnaire Ratings: Sports Activity Factors (N = 12)

Code	Indicator	M	SD	CV	Interpretation
D1	Physical contact & collision	4.75	0.45	0.10	Extremely important
D2	High-speed/high-altitude	4.67	0.49	0.11	Extremely important
D3	Technical complexity	4.42	0.67	0.15	Extremely important
D4	Duration and intensity	3.92	0.29	0.07	Very important
D5	Competitive pressure	3.83	0.39	0.10	Very important

Table 13. Round 2 Expert Questionnaire Ratings: Social and Psychological Factors (N = 12)

Code	Indicator	M	SD	CV	Interpretation
E1	Risk perception level	4.75	0.45	0.10	Extremely important
E2	Peer pressure	4.08	0.51	0.13	Very important
E3	Anxiety & psychological distress	4.08	0.67	0.16	Very important
E4	Social support	3.92	0.67	0.17	Very important
E5	Sports insurance coverage	4.67	0.49	0.11	Extremely important

Note. Scale: 1 = not important to 5 = extremely important. Round 2 A8 and C5 were retained by explicit panel decision because of practical importance.

Table 14. Expert Authority and Delphi Consensus Statistics

Statistic	Symbol	Value	Interpretation/test
Judgment-basis coefficient	Ca	0.900	High
Familiarity coefficient	Cs	0.850	High
Authority coefficient	Cr	0.875	High authority
Round 1 concordance	Kendall's W	0.4044	chi-square = 169.85, df = 35, p < 0.001
Round 2 concordance	Kendall's W	0.4808	chi-square = 178.84, df = 31, p < 0.001

Phase III: AHP Weight Assignment and Priority Ranking

All criterion- and indicator-level matrices met CR < 0.10. Human Factors received the largest criterion weight (0.4251), followed by Environmental

(0.2532), Management and Organizational (0.1505), Sports Activity (0.0993), and Social and Psychological Factors (0.0719).

Table 15. AHP Criterion Weights and Consistency Results

Level/domain	**Weight**	**Rank**	**lambda-max**	**CI**	**CR**
Criterion level	-	-	5.0735	0.0184	0.0164
A. Human	0.4251	1	9.1172	0.0147	0.0101
B. Environmental	0.2532	2	7.0944	0.0157	0.0119
C. Management and organizational	0.1505	3	6.1101	0.0220	0.0178
D. Sports activity	0.0993	4	5.0773	0.0193	0.0173
E. Social and psychological	0.0719	5	5.0773	0.0193	0.0173

Note. Criterion-level CR = 0.0164; all indicator-level matrices also met CR < 0.10.

The highest global priorities were safety awareness and self-protection (A3, 0.0812), pre-existing chronic conditions (A2, 0.0662), inadequate warm-up (A4, 0.0601), insufficient physical fitness (A1, 0.0557), and equipment condition and maintenance (B5, 0.0534). Together they accounted for 31.7% of the total system weight.

Table 16. Global Weights and Overall Ranking of the 32 Indicators

Rank	Code	Indicator	Category	Local Wi	Global Wi
1	A3	Safety awareness & self-protection	Human	0.1909	0.0812
2	A2	Pre-existing chronic conditions	Human	0.1558	0.0662
3	A4	Inadequate warm-up	Human	0.1414	0.0601
4	A1	Insufficient physical fitness	Human	0.1309	0.0557
5	B5	Equipment condition & maintenance	Environ.	0.2109	0.0534
6	B1	Extreme weather conditions	Environ.	0.1910	0.0484
7	A5	Poor exercise technique	Human	0.1130	0.0481
8	B4	Field and court surface	Environ.	0.1803	0.0456
9	A8	History of previous injuries	Human	0.1047	0.0445
10	B3	Venue size and layout	Environ.	0.1479	0.0374
11	A6	Fatigue and overtraining	Human	0.0869	0.0369
12	C1	Sports safety regulations	Mgmt.	0.2410	0.0363
13	C3	Emergency response plans	Mgmt.	0.2007	0.0302
14	D1	Physical contact & collision	Sports	0.2936	0.0291
15	C2	Teacher supervision quality	Mgmt.	0.1788	0.0269
16	B6	Protective barriers & padding	Environ.	0.0995	0.0252
17	C5	Medical support services	Mgmt.	0.1593	0.0240
18	B2	Air quality and pollution	Environ.	0.0901	0.0228
19	D4	Duration and intensity	Sports	0.2225	0.0221

20	A7	Poor nutrition & hydration	Human	0.0494	0.0210
21	B7	Lighting adequacy	Environ.	0.0803	0.0203
22	C4	Safety education programs	Mgmt.	0.1264	0.0190
23	E1	Risk perception level	Social	0.2564	0.0184
24	D2	High-speed/high-altitude	Sports	0.1686	0.0167
25	D5	Competitive pressure	Sports	0.1686	0.0167
26	E3	Anxiety & psychological distress	Social	0.2232	0.0161
27	E5	Sports insurance coverage	Social	0.2232	0.0161
28	D3	Technical complexity	Sports	0.1468	0.0146
29	C6	Institutional risk management	Mgmt.	0.0938	0.0141
30	E4	Social support	Social	0.1691	0.0122
31	A9	Psychological readiness	Human	0.0269	0.0115
32	E2	Peer pressure	Social	0.1282	0.0092

Note. Global weight = local weight multiplied by criterion weight.

Integrated Discussion of Objectives 1, 2, and 3

The predominance of human factors in the weighted framework is consistent with Ge et al. (2020), Cui and Yan (2022), and Li et al. (2023), who identified physical condition, inadequate experience, and limited safety awareness as central sources of sports injury risk among college students. However, the present study extends these findings by distinguishing the relative importance of individual indicators within the human domain. Safety awareness and self-protection capability (A3) received the highest global weight of all indicators, exceeding pre-existing chronic conditions (A2), inadequate warm-up (A4), insufficient physical fitness (A1), and history of previous injuries (A8). This pattern suggests that sports risk is not determined solely by relatively stable physical characteristics, but is also shaped by modifiable cognitive and behavioral factors. The student questionnaire supports this interpretation, as inadequate warm-up was the highest-rated physical concern (M = 3.93), and 60% of respondents identified insufficient warm-up or cool-down practices as a risk factor.

Furthermore, from the perspective of the Health Belief Model (Rosenstock et al., 1988), students who underestimate their susceptibility to injury or overestimate their ability to manage exercise demands may fail to adopt preventive behavior even when facilities and supervision are adequate. The convergence between student-reported behavior and expert-derived weighting therefore underscores the importance of safety education, self-monitoring, and preventive preparation in reducing sports participation risk.

A notable divergence emerged between student perceptions and expert priorities. Students gave the highest strategy ratings to mandatory pre-participation health screening and the provision of on-site medical or first-aid personnel, both with a mean of 4.27. In contrast, medical support services (C5) ranked 17th in the expert-derived global weighting system, while pre-

participation screening was represented only indirectly through indicators such as pre-existing chronic conditions, medical support services, and institutional risk management. A similar contrast appeared in the psychological domain. Students identified academic stress as the leading psychological concern (M = 3.80), whereas the expert framework assigned the lowest criterion-level weight to Social and Psychological Factors (0.0719). These differences should not be interpreted as contradictions. Rather, they reflect distinct evaluative standpoints. Students are more likely to emphasize directly experienced service gaps, immediate stressors, and visible institutional support, while experts tend to prioritize broader causal pathways and system-level risk structures. The retention of A8 and C5 during the Delphi process, despite their failure to meet the usual statistical screening threshold, further demonstrates that practical significance cannot always be captured by mean scores and coefficients of variation alone. This finding suggests that sports risk frameworks should combine statistical criteria with expert judgment, particularly when evaluating low-frequency but potentially high-consequence risks.

Management and Organizational Factors ranked third in criterion weight (0.1505), below Human and Environmental Factors. Nevertheless, this lower ranking does not imply limited practical importance. Chang and Wang (2022) documented that deficiencies in school PE risk management mechanisms—including unclear responsibility allocation, inadequate supervision, and absent emergency protocols—amplify risks originating in both the individual and environmental domains. Chen et al. (2023) and Xu et al. (2023) similarly argued that institutional risk management functions as a system-level lever: a single policy intervention (for example, mandatory pre-participation screening or systematic facility inspection) can simultaneously mitigate multiple human and environmental risk factors. In the present framework, sports safety regulations (C1), teacher supervision quality (C2), and emergency response plans (C3) all occupy relatively high positions within their domain. The practical implication is that universities should not view management investment as secondary to individual behavior change; rather, institutional policy and supervision constitute the infrastructure through which individual-level and environmental-level interventions are delivered and sustained.

Although Sports Activity Factors received a lower criterion-level weight than Human, Environmental, and Management and Organizational Factors, the ranking of physical contact and collision intensity (D1) indicates that the inherent characteristics of specific sports remain important. This finding is consistent with Greier et al. (2018), Rauh et al. (2021), and Yan and Tian (2020), who reported that collision, rapid movement, technical complexity, and sport-specific demands contribute substantially to injury exposure. However, the present results suggest that the inherent danger of a sport does not operate independently. Its effect is likely to increase when students have inadequate physical preparation, poor technique, insufficient warm-up, or limited supervision. Thus, sport-specific risk should be interpreted as an interaction between activity demands and participant readiness rather than as an unavoidable property of the activity itself.

Social and Psychological Factors received the lowest criterion-level weight, but this should not be interpreted as evidence that psychological variables are unimportant. Students identified academic stress, competition-related anxiety, and pressure to participate despite inadequate readiness as meaningful concerns. These findings indicate that psychological factors may operate primarily as moderating or situational influences rather than as direct injury causes. For example, stress and anxiety may reduce concentration, weaken decision-making, and increase the likelihood that students ignore physical warning signs. This interpretation is consistent with Self-Determination Theory, which emphasizes the influence of autonomy, competence, and relatedness on behavioral regulation and safe participation (Ryan & Deci, 2000). The comparatively lower expert weight may therefore reflect indirect causal influence rather than limited practical relevance.

Methodologically, the present study extends previous research by integrating student questionnaire data, expert interviews, two Delphi rounds, and AHP weighting within a single sequential design. Much of the earlier research on sports risk in Chinese educational settings has been descriptive or taxonomic, identifying broad categories of risk without establishing their relative importance (Wu, 2019; Xiao, 2021; Zhao, 2022). By contrast, the present study not only identified relevant risk domains but also produced a 32-indicator hierarchy with explicit local and global weights. This structure allows universities to distinguish between broadly important domains and specific operational priorities. Nevertheless, the findings must be interpreted within several limitations. The AHP weights represent expert judgments concerning relative importance and do not estimate the probability, incidence, or causal effect of sports injuries. The student sample of 30 respondents provides descriptive corroboration rather than population-representative prevalence estimates. In addition, the framework reflects a single period of data collection and may not capture seasonal changes, sport-specific variation, or institutional differences across Changchun.

CONCLUSIONS AND RECOMMENDATIONS

This study integrated evidence from 30 students enrolled in physical education-related programs and 12 experts. Student responses identified physical, psychological, environmental, facility, and organizational concerns and supported preventive strategies centered on screening, education, equipment and facility maintenance, medical support, and individualized activity. Literature review and expert interviews generated candidate indicators; two Delphi rounds refined them to 32 indicators with high expert authority and significant concordance; and AHP assigned internally consistent local and global weights. Human factors were most influential, followed by environmental, management and organizational, sports activity, and social and psychological factors.

Together, the student perceptions and expert-derived weights offer Changchun universities a transparent basis for prioritizing safety education, health screening, facility maintenance, winter hazard control, emergency preparedness, and resource allocation. The student results are descriptive for the

30 respondents, while the AHP weights express expert-assessed relative importance rather than observed prevalence or injury probability. Future research should validate the framework with larger student samples across institutions, sports, and seasons and examine implementation outcomes and longitudinal stability.

FURTHER STUDY

Future research is encouraged to examine additional risk factors and broader student populations to strengthen the evaluation framework and improve its applicability.

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