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Biopsychosocial approach to sports injury: a systematic review and exploration of knowledge structure

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Abstract

Background Sports injuries are influenced by biological, psychological, and social factors. Therefore, an integrated approach to address these factors is essential. This study aimed to analyze the research trends and biopsychosocial factors influencing sports injuries. It also explored the knowledge structure of the biopsychosocial approach to sports injuries.

Methods A literature search was conducted using the PubMed, Cochrane Library, and RISS databases with the keywords 'Biopsychosocial' and 'Sports injury' for studies published between January 1, 2014, and August 31, 2024. Studies in which the abstract content did not match the purpose of this study were excluded. Two independent reviewers conducted a qualitative content analysis of the selected literature. Data on the study design, year of publication, biopsychosocial factors, and main findings were extracted. To explore the knowledge structure, a keyword-network analysis was performed using Python NetworkX.

Result Five studies were selected based on the inclusion and exclusion criteria. All selected studies were published after 2021, reflecting recent research trends. Biopsychosocial factors influencing the occurrence of sports injuries include sex, team sports, neuroticism, previous injury, postpartum-related factors, mental health, and sleep status. Biopsychosocial factors influencing return to play after sports injury include self-reported knee function and psychological readiness to return to sport. The five most frequently occurring keywords were 'injury', 'factors', 'sports', 'pain' and 'runners'. 'Factors-injury' had the highest co-occurrence frequency, and the 'injury', 'factors', and 'sports' showed high scores in the centrality analysis.

Conclusion A biopsychosocial approach to sports injuries represents a recent research trend. Identifying the biopsychosocial factors of sports injuries can help prevent injuries and promote rehabilitation. Therefore, the development of a biopsychosocial model to prevent sports injuries and promote rehabilitation has been proposed.

Keywords Sports injury, Biopsychosocial approach, Keyword-network analysis, Risk factor

Background

Physical activity has beneficial effects on health. It contributes to reduced mortality due to cardiovascular diseases, endocrine disorders, and cancer [1, 2]. Sports are good activities that increase physical activity. However, injuries can occur during sports activities. A study of elite athletes who had participated in the London Olympics reported an injury rate of 128.8 per 1,000 athletes. Injury rates are particularly high in sports such as taekwondo,

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soccer, and BMX [3]. A study of elite athletes who had participated in the Rio Olympics reported an injury rate of 9.8 per 100 athletes. Injury rates are particularly high in sports, such as BMX, boxing, and mountain bike cycling [4]. Injuries are prevalent during recreational sports [5, 6].

Injuries result in significant socioeconomic costs. Socioeconomic costs include the direct costs of medical expenses and social costs from absenteeism. Running-related injuries resulted in medical costs of €38.99 per injury and social costs of €38.99 per absenteeism [7]. Conversely, injury prevention can lead to savings in socioeconomic costs. Previous injury prevention resulted in cost savings ranging from €24.82 to €462 per player [8]. Therefore, injury prevention is crucial as it can help mitigate the costs associated with sports-related injuries.

To prevent sports injuries, it is important to understand their prevalence and identify risk factors. If the risk factors are identified, they can be controlled to prevent injuries. Additionally, it is important to identify the factors that help patients return to sports after rehabilitation. A successful return to sports or daily activities can be achieved by improving these factors.

Biological, psychological, and social factors influence the occurrence of sports injuries and rehabilitation. Previous research has been conducted on the biological, psychological, and social factors affecting sports injuries. Biological factors such as sex [9–11], muscle strength [12–14], and flexibility [15] affect sports injuries. Psychological factors affecting sports injuries include daily hassles, anxiety, tension, depression, and anger [16, 17].

Social factors affecting the occurrence of sports injuries include risk culture and social support [18]. Risk culture refers to the unique values and norms socialized among athletes and refers to a culture that tolerates pain, takes risks, and rejects one's limitations. Social support includes emotional, informational, and practical support. Emotional support refers to caring for and empathizing with others, and providing psychological comfort. Informational support refers to the provision of information and advice on the rehabilitation process. Practical support refers to the provision of financial or practical assistance to recover from an injury.

The importance of interdisciplinary studies has been emphasized. Health is affected by both the body and mind, and social factors also play an important role. Therefore, integrating biological, psychological, and social factors is important when treating sports injuries.

Brewer and Redmond [18] emphasized that the process from the onset of a sports injury to return to sports should be approached from a biopsychosocial perspective. When addressing sports injuries, biological systems such as the musculoskeletal, cardiovascular, and nervous

systems should be identified. They also emphasized that psychological aspects of injured athletes such as emotions, cognition, motivation, and perception should be examined. Additionally, attention should be paid to the team atmosphere, risk culture, and social support.

This study aimed to identify research trends in biopsychosocial approaches to sports injuries and the influence of biopsychosocial factors on sports injuries. In addition, this study aimed to identify the knowledge structure of the biopsychosocial approach to sports injuries using keyword-network analysis. The research questions according to the purpose are as follows:

- What is the current status of research on the biopsychosocial approach to sports injuries?
- What are the biopsychosocial factors that influence sports injuries?
- What are the main keywords related to the biopsychosocial approach to sports injuries and the co-occurrence frequency and centrality between keywords?

Key Terms

Biopsychosocial approach

The biopsychosocial approach is an integrated approach that examines biological, psychological, and social factors to identify the causes and treatment of disease. In this study, the biopsychosocial approach refers to an integrated approach that considers the biological, psychological, and social factors associated with the occurrence, recovery, and return to play of sports injuries.

Biopsychosocial factors

Biopsychosocial factors refer to the biological, psychological, and social factors that identify the causes and treatment of a disease. In this study, biopsychosocial factors referred to biological, psychological, and social factors related to the occurrence, recovery, and return to play of sports injuries.

Keyword-network analysis

Keyword-network analysis is a network-based content-analysis method that extracts keywords from the text, constructs a network based on their co-occurrence and other relationships, and analyzes the semantic content of the text.

Method

This study reviewed the literature to identify research trends on the biopsychosocial approach to sports injuries and biopsychosocial factors affecting sports injuries. Keyword-network analysis was conducted to explore the

knowledge structure of the biopsychosocial approach to sports injuries. The literature selection and review processes followed the PRISMA guidelines [19]. This study did not conduct a meta-analysis, but a qualitative analysis of the literature and a keyword-network analysis. Consequently, some items in the PRISMA checklist could not be verified. Except for these items, the study was conducted according to the PRISMA guidelines (Supplement 1). The literature collection process is illustrated in Fig. 1. The protocol for this review has not yet been registered.

Search strategy

We searched for literature published in academic journals from January 1, 2014, to August 31, 2024. Search engines used were PubMed, Cochrane Library, and RISS. The search terms used were ‘biopsychosocial’ and ‘sports

injury’. As a result of the search, 108 articles were found in PubMed, four in the Cochrane Library, and one in RISS. There were no overlapping documents between the search engines. In total, 113 studies were identified.

Eligibility criteria

The collected articles were screened according to inclusion and exclusion criteria (Table 1). Articles containing both the keywords ‘biopsychosocial’ and ‘sports injury’ in the title was prioritized for selection. Literature containing only the keyword ‘psychosocial’ in the title was excluded because the purpose of this study was to review the integrated biopsychosocial concept.

Articles that did not include ‘biopsychosocial’ or ‘sports injury’ in the title but contained keywords related to these were also selected for analysis. For example, articles

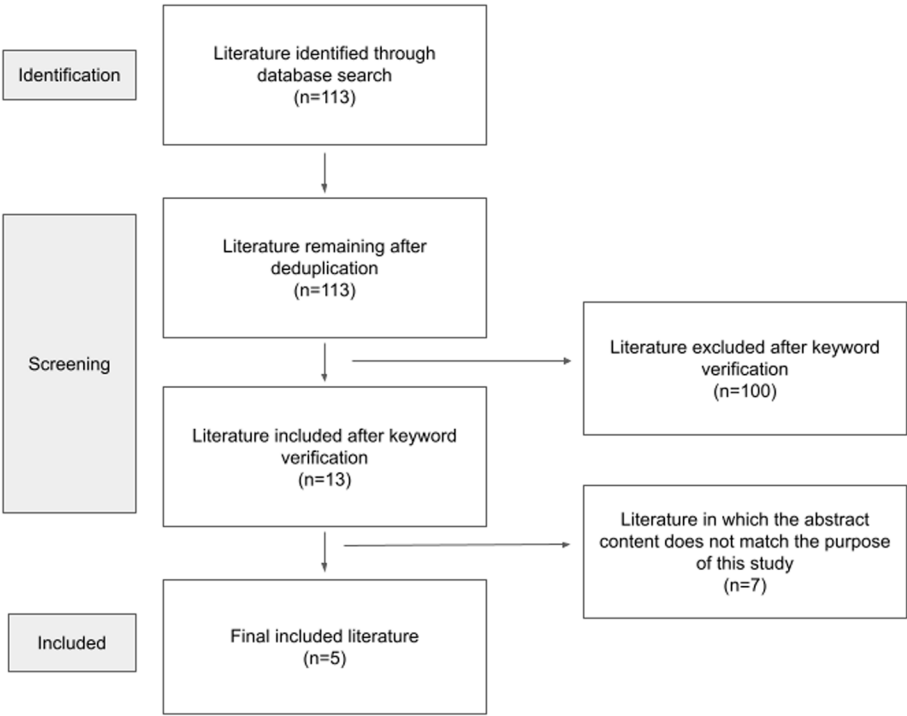


Fig. 1 Literature collection

Table 1 Literature inclusion and exclusion criteria

Inclusion	Exclusion
1. Literature published in academic journals from January 1, 2014, to August 31, 2024	Literature in which abstract content does not match the purpose of this study
2. Literature containing the keywords ‘biopsychosocial’ and ‘sports injury’ in the title	
3. Literature containing keywords related to ‘biopsychosocial’ and ‘sports injury’ in the title	

with the keyword ‘physical activity-related injuries’ were considered relevant to sports injuries and were therefore selected for analysis. Articles with the keywords ‘runners’ and ‘pain’ were also considered to be related to sports injuries and were selected for analysis. This study was not limited to elite sports. Since the recreational sports are increasing and recreational sports are important in maintaining health, articles on recreational sports were also selected.

Literature selection and data extraction

Two independent reviewers (MJ and HB) screened the literature based on the selection and exclusion criteria. MJ is the author of this study and a family medicine doctor with expertise in sports psychology. HB is a professor of sports psychology.

Thirteen articles were selected on the basis of the inclusion criteria. We then reviewed the abstracts of the studies and excluded seven that were not relevant to the purpose of this study. This study aimed to determine the effect of biopsychosocial factors on sports injuries. Studies that did not clearly identify these factors were excluded. The reviewers cross-checked each other. When the reviewers had different opinions, they discussed them until a consensus was reached. Finally, a total of five studies were selected.

Two independent researchers repeatedly read the text and extracted data from the selected literature, including study design, year of publication, biopsychosocial factors, and main findings. Our primary interest in the data was biopsychosocial factors influencing sports injuries. Additionally, the abstracts of the studies were saved as a CSV file for keyword-network analysis. The reviewers cross-checked the data. When they had different opinions, they discussed them until a consensus was reached.

Risk of bias in individual studies

The two independent reviewers evaluated the quality of the five articles. They cross-checked each other. When they had different opinions, they discussed them until a consensus was reached. These five studies included two systematic reviews, two cross-sectional studies, and one

cohort study. Two systematic reviews adhered to the PRISMA guidelines. Consequently, the quality of the studies was deemed satisfactory.

Two cross-sectional studies were evaluated using Robans-2 (Revised Risk of Bias Assessment Tool for Non-randomized Studies of Interventions-2) [20]. Robans-2 evaluates the quality of studies in the domain of ‘Comparability of the target group,’ ‘Target group selection,’ ‘Confounders,’ ‘Measurement of intervention/exposure,’ ‘Blinding of assessors,’ ‘Outcome assessment,’ ‘Incomplete outcome data,’ and ‘Selective outcome reporting.’ Robans-2 is a tool that can be applied to nonrandomized studies. Both cross-sectional studies confirmed that they had faithfully followed the research methods. They recruited participants based on specific inclusion and exclusion criteria, collected data using a validated questionnaire, and analyzed the data using regression analysis. Considering these points, we concluded that the quality of the studies was sufficient for this review (Table 2). However, cross-sectional studies have the disadvantage of being unable to confirm causal relationships between variables. Therefore, a limitation is that the biopsychosocial factors identified in the two cross-sectional studies cannot establish a clear causal relationship with injury.

One cohort study was also evaluated using the Robans-2. This study applied specific inclusion and exclusion criteria, utilized hospital medical records and a validated questionnaire, and analyzed the data using multivariate analysis. Considering these points, we concluded that the quality of the studies was sufficient for this review (Table 2).

Data synthesis

This study aimed to identify biopsychosocial factors that influence sports injuries. The reviewed literature included different study designs. Therefore, a narrative synthesis method was used to integrate the content of the literature. Two independent reviewers cross-checked the biopsychosocial factors extracted from the literature and organized them into tables.

We also conducted a keyword-network analysis to explore the knowledge structure of the biopsychosocial

Table 2 Quality assessment of the literature using Robans-2

	Risk of bias							
	D1	D2	D3	D4	D5	D6	D7	D8
Xu, L., Chen, S., Gao, D., Fang, Y., & Li, L.(2024) [21]	low	low	low	low	low	low	low	low
Christopher, S. M., Cook, C. E., & Snodgrass, S. J.(2021) [22]	low	low	low	unclear	low	low	low	low
Slater, D., Kvist, J., & Ardern, C. L.(2023) [24]	low	low	low	low	low	low	low	low

D1: Comparability of the target group, D2: Target group selection, D3: Confounders, D4: Measurement of intervention/exposure, D5: Blinding of assessors, D6: Outcome assessment, D7: Incomplete outcome data, D8: Selective outcome reporting, Robans-2: Revised Risk of Bias Assessment Tool for Nonrandomized Studies of Interventions-2

approach to sports injuries. Keyword-network analysis was performed using Python NetworkX. This was checked by two independent reviewers. The specific method of keyword-network analysis is as follows.

Keyword-network analysis

In this study, a keyword-network analysis was performed to investigate the knowledge structure of the biopsychosocial approach to sports injuries. It was conducted using Python in a Colab environment. Noun-type keywords were extracted from the abstracts of the five selected studies. Among the extracted keywords, the top 50 keywords were selected and refined. Keywords with similar meanings were integrated and keywords unrelated to the topic of the study were deleted.

The final keywords were selected using a refining process. A frequency analysis was performed on the final keywords. The co-occurrence frequency was analyzed based on how often a specific keyword appeared alongside other keywords.

In addition, a centrality analysis of the keywords was performed. Centrality is an indicator of the centrality of a specific keyword in a network. It can be measured using degree, closeness, and betweenness centralities. Keyword extraction and network analysis were performed using Python Pandas and NetworkX. The Python source code and detailed analysis process are provided in Supplement 2.

Results

Literature review

Five studies were selected through the literature collection and selection process. These studies were published in the following years: two in 2024, two in 2023, and one in 2021. Although the volume of literature was limited, recent research had been conducted using the keywords ‘biopsychosocial’ and ‘sports injury’.

The selected studies were classified into two categories (Table 3). The two categories were biopsychosocial factors influencing the occurrence of sports injuries and biopsychosocial factors influencing the return to play after sports injuries. Three articles focused on biopsychosocial factors influencing the occurrence of sports injuries, and two articles focused on biopsychosocial factors influencing the return to play after sports injuries.

Biopsychosocial factors influencing the occurrence of sports injuries

The main results of the literature related to biopsychosocial factors influencing the occurrence of sports injuries are shown in Table 4. Xu et al. [21] investigated physical activity-related injuries and biopsychosocial factors in 1051 college students. Biopsychosocial factors that

Table 3 Categories of literature related to the biopsychosocial approach to sports injuries

Content Category	Literature
Biopsychosocial factors influencing the occurrence of sports injuries	Xu, L., Chen, S., Gao, D., Fang, Y., & Li, L. (2024) [21] Christopher, S. M., Cook, C. E., & Snodgrass, S. J.(2021) [22] McClean, Z. J., Pasanen, K., Lun, V., Charest, J., Herzog, W., Werthner, P., et al. (2024) [23]
Biopsychosocial factors influencing return to play after sports injury	Slater, D., Kvist, J., & Arden, C. L (2023) [24] de Queiroz, J. H. M., Murakawa, Y. A. B., de Castro, S. S., Almeida, G. P. L., & de Oliveira, R. R. (2023) [25]

influence physical activity-related injuries include sex, team sports, ground status, and neuroticism. The occurrence of physical activity-related injuries was lower in women, and higher in those with high neuroticism, team sports, and wet ground environments.

Christopher et al. [22] investigated biopsychosocial factors related to pain in female runners after childbirth. Biopsychosocial factors related to pain in female runners after childbirth included novice runner type, postpartum accumulated fatigue score > 19, previous running injury, vaginal delivery, incontinence, and < 6.8 h of sleep on average per night. When four or more of these factors were satisfied, the probability of pain was 61.2%. By investigating these biopsychosocial factors, a biopsychosocial model could be developed to predict the probability of pain occurrence among female runners after childbirth.

McClean et al. [23] reviewed 10 studies investigating the relationship between training load, fatigue, and musculoskeletal injuries in college athletes and identified the biopsychosocial factors affecting musculoskeletal injuries. This study presents a biopsychosocial model of sports injuries in collegiate sports. This model describes the relationship between training load, allostatic load, internal load, performance fatigability, psychophysiological, and socio-ecological factors, and sports injuries. Thus, this study highlights that academic load, social load, and mental health are important factors for understanding the multifactorial nature of sports injuries in college athletes.

Biopsychosocial factors affecting return to play after sports injury

The main results of literature related to the biopsychosocial factors affecting return to play after sports injuries are shown in Table 5. Slater et al. [24] identified biopsychosocial factors affecting return to play in 88 patients

Table 4 Biopsychosocial factors influencing the occurrence of sports injuries

Researchers (Year)	Method	Biopsychosocial factors	Main findings
Xu, L., Chen, S., Gao, D., Fang, Y., & Li, L.(2024) [21]	cross-sectional study	sex, team sports, ground status, neuroticism	Women are less likely to sustain sports injuries than men Team sports, higher levels of neuroticism, and a wet ground environment are associated with higher rates of physical activity-related injuries
Christopher, S. M., Cook, C. E., & Snodgrass, S. J.(2021) [22]	cross-sectional survey	runner type-novice, postpartum accumulated fatigue score > 19, previous running injury, vaginal delivery, incontinence, < 6.8 h of sleep on average per night	Runners after childbirth who have four or more of the six biopsychosocial risk factors had a 61.2% chance of running-related pain
McClean, Z. J., Pasanen, K., Lun, V., Charest, J., Herzog, W., Werthner, P., et al. (2024) [23]	systematic review	academic load, social load, mental health	A biopsychosocial model of sports injuries in college sports is presented Academic load, social load, and mental health are important factors in understanding the multifactorial nature of sports injuries in college athletes

Table 5 Biopsychosocial factors influencing return to play after sports injury

Researcher (Year)	Method	Biopsychosocial factors	Main findings
Slater, D., Kvist, J., & Arden, C. L.(2023) [24]	prospective single cohort study	self-reported knee function, psychological readiness to return to sport	The better the self-reported knee function at 6 months after injury and the psychological readiness to return to sport at 12 months after injury were associated with higher probability of returning to sports
de Queiroz, J. H. M., Murakawa, Y. A. B., de Castro, S. S., Almeida, G. P. L., & de Oliveira, R. R. (2023) [25]	systematic review	body functions, activity & participation, body structure, environmental factors, personal factors	Current CPGs for return to sport after an ACL injury do not adequately address the biopsychosocial domain There is a need for CPGs that fully address the biopsychosocial model

CPG Clinical practice guidelines, ACL Anterior Cruciate ligament

who did not undergo surgery after anterior cruciate ligament rupture. Better self-reported knee function 6 months after injury and better psychological readiness to return to play 12 months after injury were associated with a higher probability of returning to sports.

De Queiroz et al. [25] reviewed seven clinical practice guidelines (CPGs) to determine whether biopsychosocial factors were adequately included in CPGs for return to sport after anterior cruciate ligament injury. The most frequently included biopsychosocial domains in the CPGs were body function (37.77%), activity and participation (20.00%), body structure (13.3%), environmental factors (11.11%), and personal factors (8.88%). CPGs primarily emphasize physical factors and do not satisfactorily address biopsychosocial factors. Therefore, they emphasized the need for CPGs that sufficiently address the biopsychosocial model domain.

Biopsychosocial factors that influence the occurrence of sports injuries include sex, team sports, neuroticism,

previous injury, postpartum-related factors, sleep status, academic load, social load, and mental health. Biopsychosocial factors influencing return to play after sports injury include self-reported knee function and psychological readiness to return to sports. Body function, activity and participation, body structure, environmental factors, and personal factors were not synthesized as factors affecting sports injuries, because they were the only domains for evaluating CPGs.

Keyword frequency, keyword co-occurrence analysis

Noun keywords were extracted from the literature abstracts using Python. The keywords with the same meaning were integrated. The keywords 'injuries' and 'injury' were integrated into 'injury', and 'variables' and 'factors' were integrated into 'factors'. In addition, nouns such as 'CI', 'months', and 'ICF', which were unrelated to the topic of this study, were deleted. Consequently, 21 keywords were selected for the analysis (Table 6).

Table 6 Keywords selected from abstracts

Keyword	Frequency	Keyword	Frequency
injury	35	fatigue	5
factors	30	RTS	5
sports	18	relationship	4
pain	13	knee	4
runners	11	quality	4
model	10	preinjury	4
risk	10	tool	4
ACL	10	performance	3
CPGs	8	athletes	3
postpartum	7	prevention	3
load	6		

ACL Anterior Cruciate ligament, CPGs Clinical Practice Guidelines, RTS Return to Sports

The top ten keywords with the highest frequency were ‘Injury’, ‘factors’, ‘sports’, ‘pain’, ‘runners’, ‘model’, ‘risk’, ‘ACL(Anterior Cruciate Ligament)’, ‘CPGs(Clinical Practical Guidelines)’, and ‘postpartum’.

The top ten keywords with the highest co-occurrence frequency are listed in Table 7. The keywords with the highest co-occurrence frequency were ‘factors’ and ‘injury’. ‘Factors’ also showed high co-occurrence frequency with ‘pain’ and ‘risk’. It was identified that ‘injury’, ‘pain’, ‘risk’, and ‘factors’ were connected as main keywords. Based on keywords and co-occurrence frequencies, identifying the risk factors for injury and pain was the main knowledge structure in the biopsychosocial approach to sports injuries.

Keyword centrality analysis

Degree, betweenness, and closeness centralities were measured (Table 8). Degree centrality is an indicator of the extent to which a specific keyword is connected to another. The top 10 keywords for degree centrality were ‘injury’ (0.850), ‘factors’ (0.800), ‘sport’ (0.750), ‘model’ (0.700), ‘risk’ (0.500), ‘fatigue’ (0.500), ‘ACL’ (0.450), ‘athletes’ (0.450), ‘prevention’ (0.450), and ‘load’ (0.400). ‘Injury’, ‘factors’, ‘sports’, and ‘model’ had relatively high

Table 8 Keyword centrality analysis

Keyword	Degree Centrality	Betweenness Centrality	Closeness Centrality
injury	0.850	0.162	0.869
factors	0.800	0.197	0.833
sport	0.750	0.111	0.800
pain	0.250	0.000	0.512
runners	0.250	0.000	0.512
model	0.700	0.068	0.769
risk	0.500	0.055	0.666
ACL	0.450	0.020	0.645
CPGs	0.300	0.000	0.540
postpartum	0.250	0.000	0.512
load	0.400	0.000	0.625
fatigue	0.500	0.023	0.666
RTS	0.300	0.000	0.540
relationship	0.400	0.000	0.625
knee	0.300	0.006	0.588
quality	0.350	0.008	0.606
preinjury	0.200	0.000	0.512
tool	0.400	0.032	0.625
performance	0.150	0.000	0.500
athletes	0.450	0.002	0.645
prevention	0.450	0.002	0.645

ACL Anterior Cruciate ligament, CPGs Clinical Practice Guidelines, RTS Return to Sports

scores of degree centrality. When considering the literature-content analysis, the ‘risk factors of sports injury’ and ‘sports injury models’ were identified to play an important role in the knowledge structure. ‘ACL’ showed an intermediate score of degree centrality, suggesting that ACL injuries have been studied importantly. ‘Fatigue’, ‘Prevention’, and ‘load’ also had intermediate scores of degree centrality. Thus, the effects of load and fatigue on injury and injury prevention have been extensively studied.

Betweenness centrality is an indicator of the extent to which a specific keyword acts as a mediator for other keywords. A high betweenness centrality score indicates that a specific keyword has a significant influence by mediating the connections between other keywords. In this study, the keywords generally showed low betweenness centrality. Betweenness centrality showed ‘factors’ (0.197), ‘injury’ (0.162), ‘sport’ (0.111), ‘model’ (0.068), ‘risk’ (0.055), ‘tool’ (0.032), ‘fatigue’ (0.023), ‘ACL’ (0.020), ‘quality’ (0.008), and ‘knee’ (0.006) as the top 10 keywords. Among them, ‘factors’ showed the highest betweenness centrality. This indicates that ‘factors’ serve as a link between other keywords within the network.

Closeness centrality is an indicator of how close a specific keyword is to other keywords. A high closeness

Table 7 Keyword co-occurrence frequency

Keyword	Frequency	Keyword	Frequency
factors-injury	19	pain-runners	10
injury-sport	15	injury-model	9
ACL-injury	12	pain-risk	9
factors-pain	11	injury-load	8
factors-risk	11	postpartum-runners	8

ACL Anterior Cruciate ligament

centrality indicates that the keyword plays a central role in the network. The top 10 keywords for closeness centrality were 'injury' (0.869), 'factors' (0.833), 'sport' (0.800), 'model' (0.769), 'risk' (0.666), 'fatigue' (0.666), 'ACL' (0.645), 'athletes' (0.645), 'prevention' (0.645), and 'load' (0.625). The top ten closeness centrality followed the same order as the top ten degree centrality. Therefore, the 'risk factors for sports injury' and 'sports injury models' strongly influenced the knowledge structure of the biopsychosocial approach to sports injuries. The keyword-network map is shown in Fig. 2. The size of the node was proportional to the degree centrality, and the width of the edge was proportional to the weight.

Discussion

This study reviewed the literature to identify research trends in biopsychosocial approaches to sports injuries and the influence of biopsychosocial factors on sports injuries. In addition, keyword-network analysis was conducted to identify the knowledge structure of the biopsychosocial approach to sports injuries.

Five studies were reviewed using the inclusion and exclusion criteria. Although not much of the literature was reviewed, these studies were published after 2021. Recently, a biopsychosocial approach to sports injuries has been identified as a research trend.

The main components of the psychosocial approach to sports injuries were classified into 'biopsychosocial factors affecting the occurrence of sports injuries' and 'biopsychosocial factors affecting return to play after sports injuries'. Biopsychosocial factors influence the occurrence of sports injuries and include sex, team sports, neuroticism, previous injury, postpartum-related factors, sleep status, academic load, social load, and mental health. Biopsychosocial factors influencing return to play after sports injury included self-reported knee function and psychological readiness to return to sports. The keyword-network analysis showed that the keywords 'injury', 'factors', and 'sports' had the highest frequencies. Co-occurrence frequency and centrality were also high.

This study did not review the literature separately addressing the biological, psychological, and social factors associated with sports injuries. This study reviewed

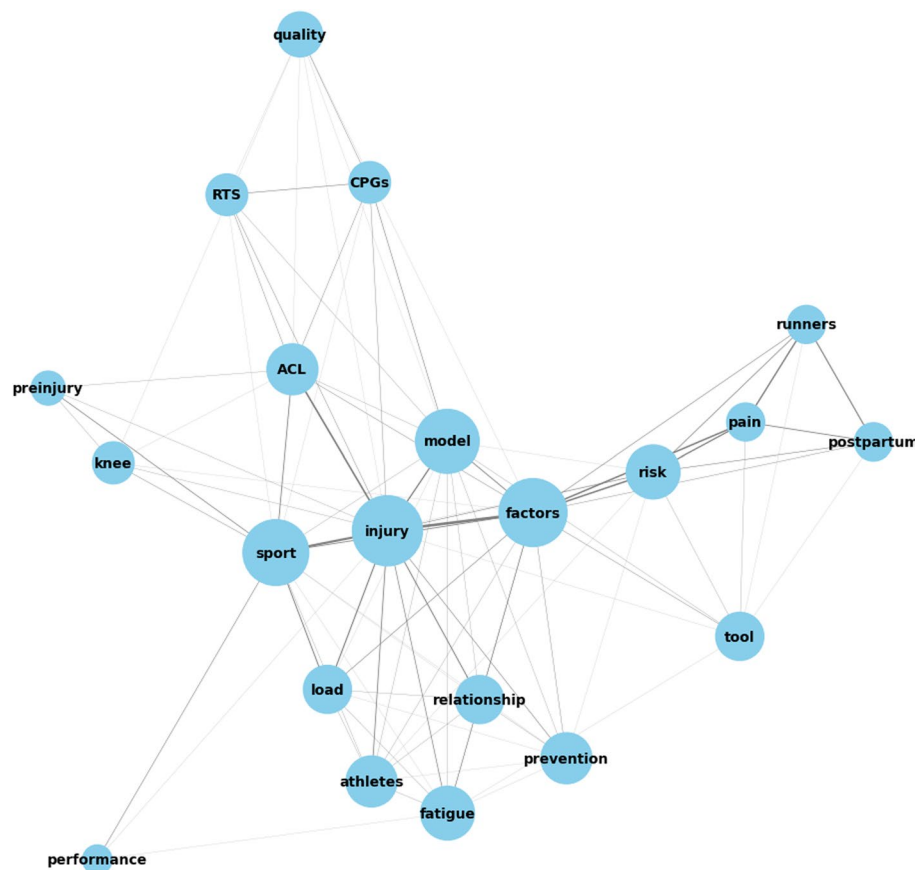


Fig. 2 Network map of the biopsychosocial approach to sports injuries. Legends: ACL: Anterior Cruciate ligament, CPGs: Clinical Practice Guidelines, RTS: Return to Sports

literature on sports injuries from an integrated biopsychosocial perspective. Many previous studies have separately analyzed the biological, psychological, and social factors of sports injuries. Muscle strength is a biological factor that affects the occurrence of sports injuries. Hietamo et al. [26] investigated whether lower extremity muscle strength is a risk factor for acute ankle injuries in adolescent athletes. Khayambashi et al. [27] investigated whether hip muscle strength in athletes could predict the occurrence of noncontact anterior cruciate ligament injuries. Steffen et al. [28] investigated the relationship between lower extremity muscle strength and the risk of noncontact anterior cruciate ligament injury in elite female soccer players. Although conclusions on whether muscle strength affects the occurrence of sports injuries varied among studies, identifying the biological factors affecting the occurrence of sports injuries plays an important role in the prevention and treatment of sports injuries.

Previous studies have also identified psychological and social factors that influence sports injuries. Motivation, confidence, and fear reduction play positive roles in rapid and successful recovery after sports injuries [29]. Fear, anxiety, and confidence are the main psychological factors that affect rehabilitation outcomes [30]. Life event stress, body characteristic anxiety, distrust, and ineffective coping skills are the main psychological factors predicting sports injuries in young soccer players [31]. Athletes who received sufficient social support from athletic trainers during the post-injury rehabilitation process had lower levels of depression and anxiety before returning to play than those who did not [32].

Several studies have examined the biological, psychological, and social factors associated with sports injuries. However, few studies have investigated this in an integrated manner. A biopsychosocial approach to sports injuries is a recent research trend and further research is needed in this regard. Christopher et al. [22] investigated the biopsychosocial factors of pain in female runners after childbirth and created a model to predict pain in female runners after childbirth. Creating such a predictive model is important because it can prevent sports injuries. Therefore, it is necessary to identify the biopsychosocial factors associated with sports injuries and create an injury prediction model.

In this review, social factors were addressed relatively less than biological and psychological factors. Social support can help injured athletes recover physically and psychologically. Social support can help buffer the stress experienced by injured athletes and reduce their anxiety and feelings of isolation [33]. Social support can be measured with the Multidimensional Scale of Perceived Social Support (MSPSS) [34]. The MSPSS is a tool that

quantitatively measures social support from family, friends, and significant others. Using a social support measurement tool, such as the MSPSS, it would be possible to quantitatively evaluate the impact of social support from family, friends, and significant others on the recovery of injured athletes.

In this review, the biopsychosocial factors influencing the return to play were considered only in relation to ACL injuries. Thus, ACL injuries are the most actively researched in relation to this topic. However, injuries other than ACL injuries can also occur during sports activities. In soccer, injuries frequently occur in the ankle, lower limbs, head, and neck [35]. In baseball pitchers, elbow injuries are common [36]. Therefore, a biopsychosocial approach that focuses on various areas such as the ankles and elbows is necessary. Thus, I propose a study to identify the biopsychosocial factors influencing the return to sports after injuries in various areas, such as the ankle and elbow.

As a result of the keyword-network analysis, 'injury' had the highest scores in frequency, degree centrality, and closeness centrality. This result implies that 'injury' is closely connected to other keywords and plays a central role within the network. This result is thought to have been obtained because 'injury' was a search term and the main topic of this review.

'Factors' showed the highest scores for frequency, degree centrality, and closeness centrality, followed by 'injury'. 'Factors' also showed the highest score in between centrality. This result implies that 'factors' are closely connected to other keywords, play a central role, and also serve as a link between other keywords within the network.

Specifically, 'factors' is closely connected to keywords such as 'injury', 'sport', 'model', 'risk', 'fatigue', 'ACL', 'athletes', 'prevention', and 'load' and plays a role in connecting these keywords within the network. The keyword combination 'injury—factors—risk' indicates that identifying risk factors for injury is a main knowledge structure within the biopsychosocial approach to sports injuries. The keyword combination 'prevention—factors—injury' indicates that identifying the factors for injury prevention is a main knowledge structure within the biopsychosocial approach to sports injuries. These results suggest that identifying the risk factors for injury and factors for injury prevention could be important research topics in biopsychosocial approaches to sports injuries.

This review was limited in that it only reviewed five studies and did not include Randomized Controlled Trial (RCT). However, it was confirmed that all studies were conducted according to each research design. All the literature was published after 2021, reflecting recent research trends. This review also provides meaningful

Table 9 Medical checkup for elite athletes using biopsychosocial approach

Biological	History taking	Current Problem, Past History, Family History, Alcohol consumption, Smoking, menstruation(women)
	Physical exam	Musculoskeletal system, Heart, Lung, Abdomen, Nervous system, Ear, Nose, mouth, Eyes, and Skin
	Laboratory exam	Hemoglobin, AST, ALT, r-GTP, Total bilirubin, BUN, Creatinine, eGFR, fasting glucose, TSH, Urine analysis
	Radiology exam (if necessary)	CT(brain), MRI, Ultrasonography
	BMD	
	EKG	
Psychological	Depression	PHQ-9
	Anxiety	Sport Competition Anxiety Test
	Premenstrual Symptoms(women)	Premenstrual Symptoms Screening Tool
Social	Social Support	MSPSS
	Economic status	

PHQ-9 Patient Health Questionnaire-9, MSPSS Multidimensional Scale of Perceived Social Support, BMD Bone Mineral Density, EKG Electrocardiography

information for follow-up studies, such as the development of biopsychosocial factors for injury prevention.

Conclusions

Approaching sports injuries from a biopsychosocial perspective has recently become a trend. Biopsychosocial factors that influence the occurrence of sports injuries include sex, team sports, neuroticism, previous injury, postpartum-related factors, sleep status, academic load, social load, and mental health. Biopsychosocial factors influencing return to play after sports injury include self-reported knee function and psychological readiness to return to sports.

The ten most frequently occurring keywords were ‘injury’, ‘factors’, ‘sports’, ‘pain’, ‘runners’, ‘model’, ‘risk’, ‘ACL’, ‘CPGs’, and ‘postpartum’. ‘Factors—Injury’ had the highest frequency of co-occurrence. The top 10 keywords for degree centrality were ‘injury’, ‘factors’, ‘sport’, ‘model’, ‘risk’, ‘fatigue’, ‘ACL’, ‘athletes’, ‘prevention’, and ‘load’.

Identifying the biopsychosocial factors that affect the occurrence of sports injuries and return to play will help prevent injuries and promote recovery. Therefore, identifying the biopsychosocial factors that contribute to the occurrence of injury and return to play is important. Thus, I propose an RCT on the effects of biopsychosocial factors such as social support and mental health on injury occurrence and return to play. Furthermore, I propose identifying various biopsychosocial factors that could influence injury occurrence and developing an injury prediction model using regression analysis, decision trees, and deep learning, with these factors as variables.

Clinical implication

The author is a family medicine doctor with extensive experience treating elite athletes with injuries

and illnesses. Elite athletes routinely undergo medical checkups at hospitals. When they undergo medical checkups, a biopsychosocial approach may be useful. Based on the author’s clinical experience and insights from this review, the author proposes a medical checkup list for athletes (Table 9). This medical checkup is structured into biological, psychological, and social components. During this medical checkup, test items can be added or excluded depending on the hospital’s resources and environment. If an abnormality is detected during a medical checkup, a referral to a specialist is provided. For example, a high score on the PHQ-9 may suggest depression and could result in a referral to a psychiatrist.

Abbreviations

ACL	Anterior Cruciate ligament
CPGs	Clinical practice guidelines
BMD	Bone Mineral Density
EKG	Electrocardiography
MSPSS	Multidimensional Scale of Perceived Social Support
PHQ-9	Patient Health Questionnaire-9,
RTS	Return to Sports
RCT	Randomized Controlled Trial

Supplementary Information

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Supplementary Material 1.
Supplementary Material 2.

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Authors’ contributions

MJ contributed to research conception and design. MJ was involved in literature collection and analysis. MJ participated in the interpretation of results and manuscript preparation.

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Data availability

The datasets used in keyword network analysis are stored as CSV files. They are available from the corresponding author on reasonable request.

Declarations**Ethics approval and consent to participate**

Not applicable.

Consent for publication

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Competing interests

The authors declare no competing interests.

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