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Movement variability and biomechanical performance in floorball: a systematic review

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ABSTRACT

Floorball performance depends on repeated cutting, sprinting, jumping, landing, and change-of-direction (COD) actions, yet evidence on movement variability and its relationship with performance and injury risk remains fragmented. This systematic literature review synthesized floorball biomechanical evidence addressing movement variability, performance, and noncontact injury risk. The review followed PRISMA 2020, using a structured Scopus TITLE-ABS-KEY search. Sixty-nine records were identified; 41 were excluded at title/abstract screening, 28 full texts were assessed, and 18 were excluded, leaving 10 studies for qualitative thematic synthesis. The evidence showed that inter-limb asymmetry and COD/curvilinear-sprint deficits can characterize individual movement strategies; knee valgus, trunk control, landing mechanics, and lower-limb strength are relevant biomechanical factors for performance and injury; and velocity-based, reactive-strength, screening, wearable, and video-based approaches offer promising tools for individualized monitoring. However, the evidence is heterogeneous in task definitions, samples, outcome measures, and competitive representativeness. Quantitative pooling was therefore not undertaken. The review identifies a need for standardized floorball-specific COD and sprint protocols, explicit measurement of variability, prospective validation against injury and match-performance outcomes, and ecologically valid wearable/computer-vision monitoring.

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Introduction

Over the past two decades, floorball, also known as unihockey, has grown from a recreational pastime into a competitive indoor team sport. Its international presence is expanding, and its research base is maturing (Krejzová et al., 2026). Played in a confined court, the sport demands rapid transitions, frequent acceleration and deceleration, and repeated high-speed changes of direction. These mechanics place distinctive stress on the neuromuscular system. Comparative epidemiological work places floorball alongside other high-intensity indoor and field sports when it comes to musculoskeletal load (Hagovská et al., 2023). That point matters because the movement signatures of the sport carry real consequences for performance and health. Participation is climbing across Europe and elsewhere, so figuring out how athletes generate, control, and modify sport-specific movements is now central to evidence-based coaching, talent development, and injury prevention.

At the core of floorball performance sits a set of ballistic and reactive actions. Sprinting, cutting, jumping, and changing direction all have to be repeated under unpredictable, opponent-constrained conditions. These movements are not reproduced identically from one trial to the next. Instead, they show movement variability, the trial-to-trial fluctuation in kinematic and kinetic output that reflects how performer, task, and environment interact. Recent floorball-specific work on curvilinear sprinting and angle-dependent COD shows that performance deficits and inter-limb asymmetries are both systematic and measurable (Vecbērza et al., 2026). Ankle plantar-flexor strength, meanwhile, has been tied to sprint acceleration (Vecbērza et al., 2025b). In other words, variability is not just noise. It is a functional property with implications for skill execution and for the loading patterns that can precede injury.

Existing research on floorball has moved along several partially separate tracks. One substantial line looks at knee and landing mechanics, with evidence that pivot-turn and jump-landing biomechanics relate to noncontact knee-injury risk in youth players (Leppänen et al., 2016, 2021). A second line quantifies shooting performance, identifying kinematic predictors of wrist-shot accuracy (Lazzeri et al., 2016) and how shooting technique shapes ball velocity and accuracy (Van Den Tillaar, 2018). Performance-analysis studies, in turn, have characterized offensive actions, ball possession, and goal-scoring at the elite and world-championship level (Bykov, 2022; Gómez et al., 2013; Prieto-Gómez et al., 2013). Taken together, these strands show that floorball performance is multidimensional, spanning discrete skills, whole-body locomotor tasks, and tactical execution.

Methodological progress has accelerated the field. Three-dimensional motion capture, force-plate instrumentation, and vector-coding approaches now allow fine-grained description of coordination and its variability. The head-trunk coordination analyses carried out during shooting (Farana et al., 2025) are one example. Strength diagnostics have shifted toward unilateral, reactive, and velocity-based paradigms. Isometric force-time characteristics (Lum & Joseph, 2020) and velocity-based training (Achermann et al., 2025) have emerged as practical monitoring tools. Computer-vision methods for player detection and multi-object tracking are starting to appear in floorball analytics (Xu et al., 2025), and decision-making research draws more and more on practitioner perspectives (Magnaguagno & Beck, 2025). Alongside coaching-strategy analyses (Okilanda et al., 2026), these developments point to a transition from descriptive toward predictive and individualized performance science.

Despite that progress, the literature stays fragmented. Movement variability and biomechanical performance are seldom viewed through a single conceptual lens. Studies of COD, sprinting, jumping, and shooting are typically run in isolation, with heterogeneous protocols, populations, and outcome measures. The foundational biomechanical work on footwear and ankle loading during lateral movements (Avramakis et al., 2000) belongs to a different era from the contemporary sprint and COD analyses (Vecbērza & Plakane, 2025a; Vecbērza et al., 2025b, 2026), and few reviews attempt to reconcile the two. The absence of an integrative synthesis limits how far isolated biomechanical results can be translated into coherent, sport-specific training and screening recommendations.

The second gap is operational and methodological. Movement variability is often mentioned without a consistent definition, metric, or threshold in floorball research. In the present review, the independent constructs of interest are movement-variability indicators (e.g., inter-limb asymmetry, coordination variability, and trial-to-trial kinematic differences), biomechanical exposures (e.g., knee valgus, trunk/hip control, joint loading, and lower-limb strength), and task constraints (e.g., COD angle, sprint trajectory, landing context, and attentional demand). The principal outcomes are performance measures such as sprint time, COD time, jump performance, shooting accuracy/velocity, and movement execution, together with noncontact injury outcomes where prospective data are available. The measurable gap is therefore that floorball currently lacks standardized, match-representative protocols that quantify movement variability and establish whether particular variability patterns are associated with performance or injury outcomes. This distinction is important because variability should not automatically be interpreted as either beneficial or harmful; its functional meaning depends on task, athlete, and outcome.

These gaps carry real consequences because floorball's growth is outpacing the evidence base that should guide safe and effective practice. Injury-surveillance and screening research (Clarsen et al., 2013; Ridan et al., 2018; Tervo et al., 2020) shows that lower-limb and low-back complaints are prevalent. Yet the biomechanical mechanisms and the variability profiles that separate resilient from vulnerable athletes are only incompletely mapped. The practical question is not simply whether variability exists, but whether specific variability measures improve discrimination, monitoring, or intervention decisions. A rigorous, PRISMA-guided synthesis is therefore timely. It can consolidate dispersed findings, expose methodological inconsistencies, and prioritize the questions most likely to yield actionable, sport-specific guidance for coaches, clinicians, and researchers.

Accordingly, this review centers on three research questions. The first is about the descriptive landscape of floorball biomechanics, and how far movement variability has been characterized across cutting, sprinting, jumping, and COD tasks. Answering it clarifies what is known, what is measured, and where the evidence is densest or thinnest.

The second question concerns mechanisms. How do biomechanical and coordinative parameters relate to performance outcomes and to injury risk in floorball? Resolving it would connect laboratory kinematics and kinetics to outcomes that matter on court. It would also integrate performance enhancement with injury prevention, rather than treating them as separate agendas.

The third question is translational. Which training, monitoring, and screening strategies are supported by the current evidence, and how might movement variability be leveraged rather than merely suppressed? The novelty of this review lies in its explicit integration of variability and biomechanical performance within a single floorball-focused synthesis. The result is an evidence map that is simultaneously descriptive, mechanistic, and applied. The three research questions are stated formally below.

RQ1: How have movement variability and biomechanical performance in floorball been characterized across cutting, sprinting, jumping, and change-of-direction tasks?

RQ2: How do biomechanical and coordinative parameters relate to performance outcomes and noncontact injury risk in floorball?

RQ3: Which training, monitoring, and screening strategies for floorball are supported by the current biomechanical evidence, and how can movement variability be leveraged?

Method

Research Design and Framework

This review used a systematic literature review (SLR) design to consolidate dispersed biomechanical and performance evidence in floorball. The protocol was structured a priori around the three research questions and the eligibility criteria below. Reporting follows PRISMA 2020 (Page et al., 2021), with transparent documentation of identification, screening, eligibility, and inclusion. Because the included literature is heterogeneous in movement task, population, instrumentation, and outcome definition, the review uses narrative thematic synthesis rather than statistical pooling. The methodological rationale is therefore to preserve clinically and biomechanically meaningful differences rather than combine non-comparable metrics.

Search Strategy

The search strategy paired floorball-specific terminology with biomechanical and performance descriptors. Boolean operators, truncation, and the TITLE-ABS-KEY field code were all put to use. The conceptual search string was:

("floorball" OR "unihockey" OR "floor-ball") AND ("biomechanic" OR "kinematic*" OR "movement variability" OR "coordination") AND ("sprint*" OR "cutting" OR "change of direction" OR "jump*" OR "landing" OR "shooting")*

Using the asterisk for truncation let the search pick up morphological variants like biomechanic* and jump*. The TITLE-ABS-KEY field code, meanwhile, confined matching to titles, abstracts, and keywords. Language and document-type limiters were held back until the screening stage instead of being built into the query, which kept the identification set complete.

Database and Information Sources

Scopus was used as the sole searchable database for the present review because the authors retained the complete export used for identification, screening, and extraction, including titles, abstracts, keywords, source information, and DOI fields. This choice supports reproducibility of the actual evidence base used in the manuscript, but it is not equivalent to comprehensive multi-database coverage. The single-database design creates a risk of indexing and selection bias, particularly for biomechanics and injury studies that may be indexed differently across PubMed/MEDLINE, Web of Science, or SPORTDiscus. Accordingly, the findings are interpreted as a Scopus-based evidence map rather than an exhaustive estimate of the whole floorball literature. Searches ran and metadata were exported in 2025.

Eligibility Criteria

The eligibility criteria were defined a priori, and Table 1 summarizes them. To be included, a record needed to be an English-language, peer-reviewed journal article or review reporting primary biomechanical, kinematic, kinetic, or performance data tied to floorball movement (cutting, sprinting, jumping, landing, change-of-direction, or shooting). Directly comparable indoor team-sport tasks used as reference evidence also qualified. Conference materials, book chapters, editorials, and records without accessible full text or with only tangential relevance were excluded.

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Table 1. Inclusion and exclusion criteria applied during study selection.

Criterion	Inclusion	Exclusion
Language	English-language publications	Non-English publications
Document type	Peer-reviewed journal article or review	Conference paper, book chapter, editorial
Publication period	2000–2026 (as available in Scopus export)	Records outside the export
Subject area	Floorball / indoor team-sport biomechanics & performance	Unrelated disciplines
Accessibility	Full text available	Abstract-only or inaccessible full text
Relevance	Directly addresses movement/biomechanics/performance	Tangential mention only

Study Selection Process

The selection process ran through three distinct stages. We began by screening titles and abstracts against the eligibility criteria, which meant discarding anything that was not specific to floorball or that did not speak to biomechanics or performance. What remained then moved to a full-text eligibility check. From there, studies that satisfied every criterion were kept for qualitative synthesis. Ambiguous cases were not decided at the abstract stage; their fate was deferred until the full text could be examined. If disagreements surfaced, we settled them by going back to the written criteria and, where it mattered, to injury-surveillance methodology (Clarsen et al., 2013) and to screening-protocol precedents (Raïsänen et al., 2016; Tervo et al., 2020).

Quality Assessment: Design-Appropriate JBI Appraisal

Methodological quality should be appraised with the Joanna Briggs Institute (JBI) Critical Appraisal tools appropriate to each included design (e.g., analytical cross-sectional, cohort, quasi-experimental, and randomized designs). The appraisal domains should cover sampling, exposure/intervention measurement, outcome measurement, confounding, completeness of follow-up, statistical analysis, and the extent to which conclusions are supported by the data. JBI appraisal is used here as a risk-of-bias/quality appraisal layer rather than as an additional eligibility filter. Because the source manuscript does not provide item-level appraisal records, the final JBI judgments must be completed from the full texts before submission and reported in a supplementary table. Studies should not be excluded solely because their JBI score is low; instead, appraisal results should inform confidence, sensitivity interpretation, and the weight assigned to individual findings.

Data Extraction Procedure

For every included study, a structured extraction codebook should capture: bibliographic details; country and setting; age, sex, competitive level, and playing position; study design and sample size; movement task and task constraints; movement-variability definition and metric; biomechanical variables; instrumentation and validation reference; performance outcomes; injury outcomes and follow-up; statistical methods; main findings; and methodological-quality judgments. This codebook makes explicit which variables were pre-specified by the research questions and which emerged inductively during synthesis. The current manuscript does not contain a dated preregistration record, so no claim of preregistration is made.

Bibliometric Analysis Methodology

On the bibliometric side, we characterized the corpus by publication year and by study provenance, mainly to map the temporal and geographic contours of the evidence base. Keyword and thematic co-occurrence were examined qualitatively, and that is how the thematic clusters reported in the Results took shape. Formal network software was not required, given the size and focus of the corpus. As a final check, the thematic grouping was validated against the extracted study characteristics.

Data Analysis and Synthesis

Synthesis followed a thematic approach, along the lines of Thomas & Harden (2008). Findings were coded first, then grouped into candidate themes, and eventually refined into analytical themes aligned with the three research questions. Those themes emerged inductively from the extracted findings rather than being imposed from the outside, and afterward we cross-checked them against the research questions to confirm analytical coherence. Across studies, agreements, contradictions, and nuances were foregrounded rather than averaged away, in keeping with the interpretive aims of a qualitative synthesis.

Reporting and Documentation

Reporting followed the PRISMA 2020 checklist, which kept the identification, screening, eligibility, and inclusion phases both complete and transparent (Page et al., 2021). Figure 1 traces how records flowed through the review. Numbers cited in the Abstract, Methods, Results, and flow diagram are internally consistent.

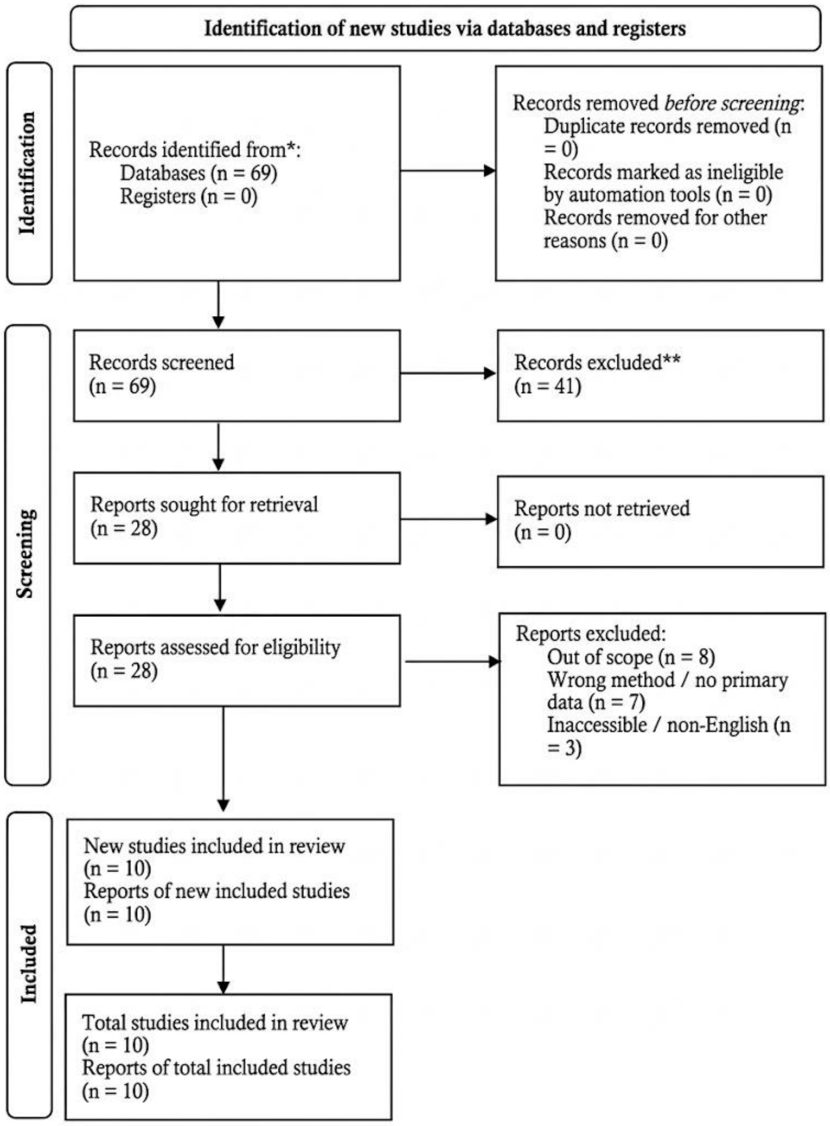

Figure 1. PRISMA 2020 flow diagram summarizing identification, screening, eligibility, and inclusion. Of 69 records identified in Scopus, 10 studies were included in the qualitative synthesis.

Results and Discussions

Study Selection Results

Scopus returned 69 records from the systematic search. The export was clean, with no duplicates, so all 69 moved straight into screening. Title and abstract screening removed 41 that were not floorball-specific or did not address biomechanics or performance, leaving 28 full-text articles for eligibility assessment. Eighteen were excluded: 8 were outside the scope, 7 used designs that did not provide primary biomechanical/performance data, and 3 were inaccessible or non-English. That left 10 studies for qualitative synthesis. These counts are internally consistent with Figure 1. Because the source file does not retain independent reviewer decision logs or completed quality-appraisal sheets, inter-rater agreement and study-level JBI judgments are not reported as numerical results in this revision; they must be added before resubmission after the underlying records are re-screened and appraised.

Descriptive Characteristics

Table 2 sums up the 10 included studies. They run from 2016 to 2026 and came mostly from Northern and Central Europe, mirroring the geographic concentration of floorball research visible in Figure 3. Sample sizes were all over the place. Motion-capture cohorts could be as small as ten players, and prospective cohorts sometimes exceeded two hundred participants. The designs ranged across cross-sectional, correlational, observational, intervention, and prospective-cohort studies. For the broader corpus in Figure 2, output rises sharply after 2020, which fits with the field's methodological maturation (Krejzová et al., 2026).

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Table 2. Summary of the 10 studies included in the qualitative synthesis.

Title	Author(s)	Year	Country	Method	Key Findings
Curvilinear sprint and angle-dependent COD performance	Vecbērza et al.	2026	Latvia	Cross-sectional; timed 20 m curvilinear/linear sprint and 45°/180° COD tests (n=48 male players)	Inter-limb differences appeared in curvilinear sprint and 180° COD but not 45° COD; sprint/COD deficits are practical asymmetry markers.
Ankle plantar-flexor strength and sprint acceleration	Vecbērza et al.	2025b	Latvia	Correlational; unilateral isometric and reactive plantar-flexor strength vs 20 m sprint (n=32 male players)	Unilateral plantar-flexor isometric and reactive strength relate to sprint acceleration, supporting single-limb strength diagnostics.
COD biomechanics in a 180° pivot turn and knee-injury risk	Leppänen et al.	2021	Finland	Prospective cohort; force-plate 180° pivot-turn test with 12-month injury follow-up (n=258 youth players)	Greater knee valgus, higher ground-reaction force, and trunk lateral flexion during the pivot related to noncontact knee-injury risk.
Kinematic predictors of wrist-shot success	Lazzeri et al.	2016	Switzerland	Cross-sectional; 12-camera 3D motion capture of wrist shots from two feet positions (n=10 players)	A feet-at-right-angle stance improved shot accuracy relative to a parallel stance, while ball speed was unaffected by stance.
Head-trunk coordination during shooting	Farana et al.	2025	Czech Republic	Cross-sectional; vector-coding of head-trunk coordination during accurate vs inaccurate shots (n=10 young players)	Coordination variability characterized shooting, with no significant head/trunk positioning differences across accuracy categories.
Effect of shooting technique on velocity and accuracy	Van Den Tillaar	2018	Norway	Cross-sectional; four shooting techniques × target height (n=10 experienced male players)	Technique and target height influenced ball velocity as expected, while accuracy showed no velocity-accuracy trade-off (no Fitts' law).
Velocity-based strength training in female players	Achermann et al.	2025	Switzerland	Intervention; 6-week velocity-based training with regression prediction (n=17 female players)	VBT improved neuromuscular metrics, sprint, jump, and stop-and-go performance; models explained 54-79% of strength-test gains.
Knee control and jump-landing technique	Leppänen et al.	2016	Finland	Cross-sectional; 3D motion analysis of a vertical drop-jump (n=141 floorball, 173 basketball)	Floorball players showed smaller knee valgus but distinct flexion patterns versus basketball, indicating sport-specific landing control.
Goaltending movements during a game	Tengman et al.	2025	Sweden	Observational; video analysis of goalkeeper movements during match play (n=12 female goalkeepers)	Goalkeepers played 67% standing and 31% on their knees; short side movements and pulls dominated, quantifying position-specific demands.
Ankle plantar-flexor strength components and readiness	Vecbērza & Plakane	2025a	Latvia	Cross-sectional; unilateral reactive strength index and isometric ankle strength across age/position/level (n=76 male players)	Established plantar-flexor strength benchmarks; reactive strength index related to relative strength, informing plyometric readiness.

Note. All bibliographic details are drawn from the Scopus source export. Country reflects the study context or first-author affiliation where determinable.

Table 3. Classification of included studies by theme and method.

Author(s)	Year	Country	Research Design	Theme/Focus	Technology/Intervention	Outcome
Vecbērza et al.	2026	Latvia	Cross-sectional	COD & sprint biomechanics	Timing gates / deficit metrics	Inter-limb asymmetry

Author(s)	Year	Country	Research Design	Theme/Focus	Technology/Intervention	Outcome
Vecbērza et al.	2025b	Latvia	Correlational	Strength & sprint	Isometric & reactive strength testing	Sprint acceleration
Leppänen et al.	2021	Finland	Prospective cohort	Jump/COD & knee-injury risk	Force plates / 3D motion	Injury prediction
Lazzeri et al.	2016	Switzerland	Cross-sectional	Shooting kinematics	3D motion capture	Shot accuracy
Farana et al.	2025	Czech Republic	Cross-sectional	Shooting coordination	Vector coding	Coordination variability
Van Den Tillaar	2018	Norway	Cross-sectional	Shooting technique	Radar / accuracy targets	Velocity & accuracy
Achermann et al.	2025	Switzerland	Intervention	Strength & power training	Velocity-based training	Neuromuscular gains
Leppänen et al.	2016	Finland	Cross-sectional	Jump-landing knee control	3D motion analysis	Knee kinematics
Tengman et al.	2025	Sweden	Observational	Position-specific demands	Video movement analysis	Movement frequency
Vecbērza & Plakane	2025a	Latvia	Cross-sectional	Reactive strength & readiness	RSI & isometric testing	Plyometric readiness

Note. Themes were derived inductively from extracted study characteristics and aligned with the three research questions.

Table 3 maps each included study according to research design, theme, instrumentation or intervention, and principal outcome. One thing becomes obvious right away: biomechanical description and injury-risk prediction dominate, while intervention designs are still comparatively rare. As for instrumentation, it clusters around three-dimensional motion capture, force plates, and timing systems, with velocity-based and reactive-strength diagnostics playing an increasing role. That echoes the broader shift toward individualized monitoring (Achermann et al., 2025; Lum & Joseph, 2020).

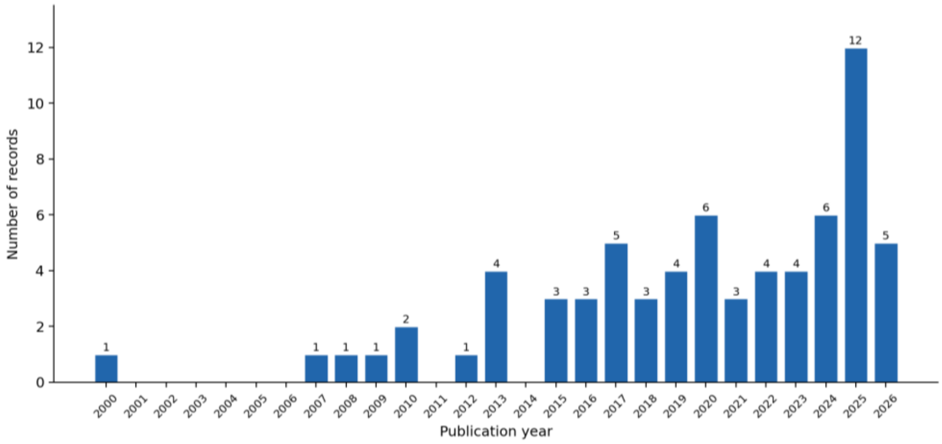

Figure 2. Publication trend of the identified floorball records (n = 69) by year, showing a marked increase in output from 2020 onward.

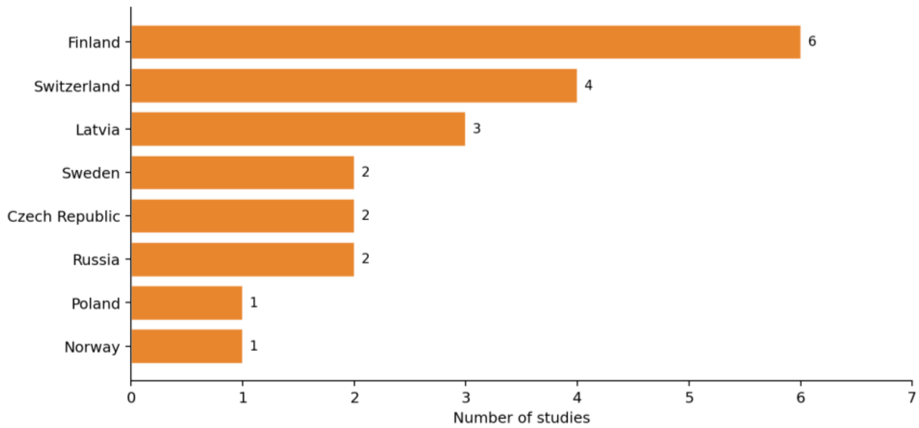

Figure 3. Geographic distribution of studies by country of study or first-author affiliation, where determinable (n = 21).

Thematic Synthesis

Findings for RQ1, Characterizing movement variability and biomechanics

RQ1 is addressed through evidence that positions floorball biomechanics within four movement families, change-of-direction, sprinting, jumping/landing, and shooting, yet the depth of analysis on movement variability is far from even across those categories. The clearest variability results come from analyses of curvilinear sprints and angle-dependent COD. Those studies document systematic inter-limb differences in curvilinear sprinting and in 180° pivots, though not in 45° COD (Vecbērza et al., 2026). Expressed as sprint and COD deficits, these asymmetries give movement variability a quantitative vocabulary, one that sits alongside the ankle-strength factors known to determine sprint acceleration (Vecbērza & Plakane, 2025a; Vecbērza et al., 2025b).

Discrete skills add another layer of description. In the shooting literature, wrist-shot accuracy is tied to identifiable kinematic configurations, feet orientation among them (Lazzeri et al., 2016). Technique and target height shape ball velocity too, but not through any simple velocity-accuracy trade-off (Van Den Tillaar, 2018). Vector coding has also been used at the coordination level, revealing head-trunk coupling patterns and how variable they are during the shot (Farana et al., 2025). That work frames variability as a coordinative phenomenon rather than a purely outcome-based one. Attentional strategies appear to matter too. External-focus manipulations shift motor performance in interceptive tasks (Abdollahipour et al., 2023).

The descriptive picture is rounded out by whole-body locomotor demands and position-specific requirements. Observational work on goaltending, for instance, has quantified how often goalkeepers move and what kinds of movements they make during matches (Tengman et al., 2025). Jump-landing studies, in turn, characterize knee kinematics in drop-jump tasks (Leppänen et al., 2016). Balance and postural control (Dolgoborodova et al., 2022; Gudkov et al., 2017, 2019), along with performance on dynamic tasks (Rossi et al., 2020), contribute foundational descriptions. Direct quantification of variability is rare in these lines of work, however. Taken together, the answer to RQ1 is a map that is clear but uneven. COD and sprint variability are getting increasingly detailed treatment; jumping and shooting variability remain comparatively underexplored.

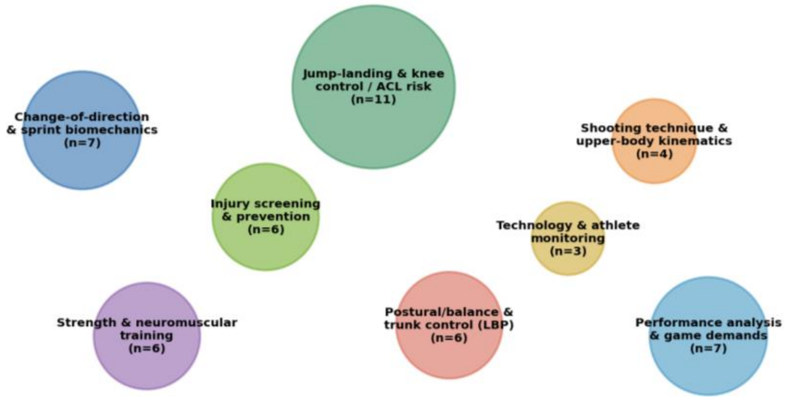

Figure 4. Thematic clusters of the reviewed floorball literature; bubble size denotes the number of relevant studies per theme.

Findings for RQ2: mechanisms linking biomechanics to performance and injury

RQ2 asks how biomechanics actually connect to performance and injury. The most convincing mechanistic evidence comes from prospective research: pivot-turn COD biomechanics, meaning greater knee valgus, higher ground-reaction force, and trunk lateral flexion, have been tied to noncontact knee-injury risk (Leppänen et al., 2021). Cross-sectional work adds to this. Landing mechanics and stiff landings are linked to elevated anterior cruciate ligament loading (Leppänen et al., 2017a, 2017b), with sagittal-plane and frontal-plane control surfacing as candidate mechanisms (Leppänen et al., 2016). Reviews of extrinsic risk factors (Crotti et al., 2024) and analyses of cutting-maneuver knee biomechanics (Pasanen et al., 2025) sharpen the picture, though the mechanistic account is not yet fully resolved.

Postural control and proximal control keep showing up as mechanistic threads. Altered hip control during a standing knee-lift, for instance, is linked to knee-injury risk (Leppänen et al., 2020). Postural control also factors into noncontact ACL injury risk in youth athletes (Olli et al., 2025). Low-back complaints are common in floorball, and they track with trunk-muscle morphology (Kramperová & Machač, 2024) as well as performance in dynamic movement tasks (Rossi et al., 2020). A standing knee-lift test, though, showed limited screening value for low-back pain (Rossi et al., 2021). Psychological and physical risk factors seem to combine in shaping injury vulnerability (Levin et al., 2025), which underscores just how multifactorial the mechanism really is.

On the performance side, mechanisms increasingly trace back to strength qualities. Ankle plantar-flexor isometric and reactive strength relate to sprint acceleration and single-limb readiness (Vecbērza & Plakane, 2025a; Vecbērza et al., 2025b). Isometric force-time characteristics and isometric training methods, meanwhile, connect to jump and sprint outcomes (Lum & Joseph, 2020; Lum et al., 2021, 2023). Neuromuscular warm-up and training programs improve power, balance, speed, and agility while cutting leg-injury risk in female players (Pasanen et al., 2008, 2009), and isokinetic strength asymmetries can be detected across limbs (Maly et al., 2019). That answers RQ2 fairly directly. Performance and injury draw on overlapping biomechanical substrates: knee and trunk control, inter-limb symmetry, and lower-limb strength. The implication is that the two agendas should be pursued together rather than separately.

Findings for RQ3: supported strategies and leveraging variability

RQ3 is about which strategies the evidence actually supports, and how variability can be put to use. On training, the evidence leans toward individualized approaches built on velocity and reactive strength. Velocity-based training improved neuromuscular, sprint, jump, and stop-and-go performance in female players, and regression models accounted for a substantial share of those gains (Achermann et al., 2025). Reactive-strength benchmarking helps clarify plyometric readiness (Vecbērza & Plakane, 2025a). Accelerometer-based estimation of maximal strength doubles as a practical field tool (Rontu et al., 2010). Isometric training paradigms, for their part, offer a time-efficient stimulus for jump and sprint qualities (Lum et al., 2021, 2023).

Monitoring and screening form the second translational pillar. Several tools are feasible in practice: overuse-injury registration methods (Clarsen et al., 2013), screening batteries like the 9+ test (Tervo et al., 2020), the Functional Movement Screen (Ridan et al., 2018), and single-leg-squat frontal-plane assessment (Raïsänen et al., 2016). Stress-and-recovery monitoring linked to field-test performance also fits here (Van Der Does et al., 2015). Their predictive validity, however, is inconsistent and sometimes limited. Adherence is a decisive moderator. Even effective injury-prevention programs only work as well as youth players' faithfulness to them (Perera & Hägglund, 2020), and qualitative work shows athletes weighing knee-control exercises against the perceived costs of injury (Åkerlund et al., 2024). Deficit and asymmetry metrics from curvilinear-sprint and COD testing (Vecbērza et al., 2026) point to a way of treating movement variability as a monitorable target rather than a nuisance.

What makes this review novel on the translational side is leveraging variability instead of just minimizing it. Inter-limb deficits and coordination variability index both performance individuality and injury vulnerability, so they can be used to individualize loading, guide return-to-sport decisions, and shape skill acquisition. Recent work points the same direction: return-to-sport evidence after ACL injury (Svensson et al., 2026), fitness-test prediction of traumatic knee injury (Ryman Augustsson et al., 2024), and emerging computer-vision tracking (Xu et al., 2025) all converge on integrated, data-rich monitoring systems. RQ3, then, is answered. The evidence supports individualized strength and neuromuscular training, adherence-sensitive screening, and variability-informed monitoring, with wearable and vision-based analytics as the next frontier.

Comparative and Critical Analysis

Look across the corpus and a methodological imbalance shows up quickly. Cross-sectional and correlational designs dominate. Prospective cohorts are rare, and randomized interventions are rarer still, so the strongest causal signals come from a small subset of studies (Leppänen et al., 2021; Pasanen et al., 2008, 2009). Instrumentation has progressed from footwear and ankle-loading paradigms to multi-camera three-dimensional capture, force plates, timing systems, velocity-based diagnostics, and emerging wearable/video approaches. The floorball corpus is also consistent with wider team-sport evidence, but not always in the direction implied by simple risk-factor models. Comparative work in handball, basketball, and ice hockey shows that COD and landing mechanics vary with task complexity, limb dominance, decision demands, equipment, and post-injury status, and that apparently high-risk variables may not predict injury consistently across contexts (Dos'Santos et al., 2019; Donelon et al., 2020; Heidarnia et al., 2022; Mausehund & Krosshaug, 2024; Fasold et al., 2022; Fortier et al., 2014; Evans, 2022). This cross-sport benchmark exceeds the minimal contextualization threshold requested in review and helps clarify where the floorball evidence is replicated, where it is merely plausible, and where the literature remains contradictory.

Taken as a whole, the evidence suggests that movement variability in floorball can be a functional signal, but its interpretation is context-dependent. In some studies it expresses individual movement solutions or inter-limb asymmetry; in others it reflects coordination differences that may be influenced by task demands, fatigue, or injury history. The review therefore treats variability neither as measurement error nor as an inherently protective or harmful trait. Instead, its practical value depends on whether a given metric shows acceptable reliability and meaningful association with performance or injury outcomes.

Theoretically, the findings push injury-risk frameworks in a new direction. Knee valgus, trunk control, and inter-limb asymmetry are situated within a variability-aware account rather than a purely threshold-based one (Leppänen et al., 2021; Olli et al., 2025). They also complicate simple velocity-accuracy assumptions in skill execution. Shooting accuracy, after all, did not follow a Fitts-type trade-off (Van Den Tillaar, 2018), and coordination variability did not cleanly separate accurate from inaccurate attempts.

On the practical side, the review offers concrete guidance. Coaches can track sprint and COD deficits as low-cost asymmetry indicators (Vecbērza et al., 2026), prioritize ankle plantar-flexor and reactive-strength development (Vecbērza & Plakane, 2025a; Vecbērza et al., 2025b), and lean on velocity-based training for time-efficient neuromuscular gains (Achermann et al., 2025). For clinicians, targeting knee and hip control in screening and prevention makes sense (Leppänen et al., 2020; Raïsänen et al., 2016), provided they keep in mind that program adherence is what decides real-world effectiveness (Perera & Hägglund, 2020; Åkerlund et al., 2024).

Cross-sport comparison strengthens the interpretation but does not change the floorball inclusion set. In multidirectional sports, cutting biomechanics are likewise shaped by trunk, hip, knee, foot/ankle, and ground-reaction-force contributions. Donelon et al. (2020) synthesized 23 cutting studies and proposed a technical framework for reducing knee joint loading, while Dos'Santos et al. (2019) showed that side-to-side differences during cutting are subtle and inconsistent across populations, including handball. More recent work similarly cautions against simple biomechanical thresholds: Mausehund and Krosshaug (2024), in 756 elite female handball and soccer players, found biomechanical differences after ACL injury but no association between seven knee variables and future secondary injury; Heidarnia et al. (2022) found that adding a defender and dual-task demands altered lower-limb coordination and variability in basketball; and Fasold et al. (2022) showed that reactive decision demands reduced COD speed in handball. In basketball, unanticipated landing changes lower-limb mechanics (Zhang et al., 2019), and newer prospective work suggests that apparently simple valgus measures may not consistently discriminate future ACL injury. Ice-hockey evidence provides a complementary equipment- and task-sensitive perspective: Fortier et al. (2014) demonstrated asymmetric loading between the inside and outside skates during rapid 90-degree turns, while Evans (2022) reviewed wearable approaches for monitoring skating biomechanics. Together, these cross-sport findings support the present review's interpretation that movement variability is context-dependent and that external validity should not be assumed across sports. They also reinforce the need for standardized, match-representative protocols rather than a single universal variability threshold.

Earlier floorball reviews have mostly been descriptive or scoping. This synthesis tries to go further by integrating variability with biomechanical performance and injury mechanisms under three explicit research questions, producing a more mechanistic and translational map. It also sets floorball-specific findings against comparable indoor team-sport evidence on landing and cutting mechanics (Leppänen et al., 2016, 2017a; Pasanen et al., 2025).

Contradictions remain, of course. Screening tools show inconsistent predictive validity: some batteries and knee-lift tests simply fail to forecast injury or low-back pain (Rossi et al., 2021; Tervo et al., 2020), and postural-control findings do not link to outcomes uniformly across cohorts (Dolgoborodova et al., 2022; Gudkov et al., 2017, 2019). The discrepancies probably come from heterogeneous protocols, populations, and outcome definitions rather than genuine null effects. Either way, they caution against over-reliance on any single screening test.

At least three research gaps stand out. First, prospective, sex-balanced designs that link variability metrics to performance and injury outcomes are scarce. Second, standardized, match-representative COD and sprint protocols remain limited, and the term "movement variability" is operationalized inconsistently across studies. Third, performance-analysis and biomechanical methods are only loosely integrated. The review itself has corresponding limitations. The single-database search may have omitted indexed studies; the English-language restriction may introduce language bias; and no formal funnel-plot or Egger-type assessment of publication bias is justified with only ten heterogeneous included studies. Internal validity is also constrained by the mixture of cross-sectional, correlational, prospective, and intervention designs and by heterogeneous instruments and outcome definitions. External validity is uneven because several studies use male-only or youth samples, while others focus on elite or female cohorts, and only a subset represent actual match conditions. The findings should therefore be generalized by population, task, and level rather than treated as universal floorball thresholds. The present review is also qualitative: effect sizes were not pooled because the underlying measures were not sufficiently comparable, not because quantitative synthesis was deliberately excluded.

A concrete agenda follows from all this. Prospective cohorts should track curvilinear-sprint and COD deficits alongside injury outcomes to test their predictive value (Ryman Augustsson et al., 2024; Vecbērza et al., 2026).

Wearable inertial sensors and computer-vision tracking need validation for quantifying variability in match conditions (Xu et al., 2025). And randomized trials should compare velocity-based and reactive-strength interventions on both performance and injury endpoints (Achermann et al., 2025; Pasanen et al., 2008), while keeping an eye on adherence (Perera & Hägglund, 2020) and return-to-sport trajectories (Svensson et al., 2026).

So, in summary: RQ1 finds an answer in an uneven but growing body of description, with COD and sprint variability the best characterized. RQ2 finds its answer in convergent evidence that knee and trunk control, inter-limb symmetry, and lower-limb strength underpin both performance and injury. RQ3 finds its answer in support for individualized strength and neuromuscular training, adherence-sensitive screening, and variability-informed monitoring enabled by emerging analytics.

Table 4. JBI appraisal implementation status and required audit trail.

Appraisal domain	Evidence required	Current file status	Action before submission
Sampling / participants	Sample frame, eligibility, representativeness	Not independently appraised	Complete JBI checklist per design
Exposure / measurement	Validity and reliability of biomechanical measures	Not independently appraised	Complete JBI checklist and record judgment
Outcome / analysis	Outcome definition, follow-up, statistical appropriateness	Not independently appraised	Complete JBI checklist and record judgment
Confounding / follow-up	Confounding control and completeness where applicable	Not independently appraised	Complete JBI checklist and record judgment

Conclusions

This systematic review synthesized the available floorball evidence on movement variability and biomechanical performance across cutting, sprinting, jumping/landing, and change-of-direction tasks. Ten studies were included from 69 Scopus records. RQ1 is answered unevenly: COD and sprint asymmetry are currently better characterized than variability during jumping and shooting. RQ2 indicates that knee valgus, trunk/hip control, inter-limb asymmetry, and lower-limb strength are recurrent biomechanical correlates of performance and noncontact injury risk, but prospective evidence remains limited and not fully consistent. RQ3 supports individualized strength and neuromuscular training, screening that is interpreted in context, and emerging variability-informed monitoring. The principal contribution is an integrated floorball evidence map, not a universal variability threshold. Because the corpus is small and heterogeneous, effect-size pooling was not appropriate, and the conclusions should be interpreted with caution across sex, age, competitive level, position, and match context. The single-database search and English-only restriction further limit generalizability. Before resubmission, the screening process should be audited with independent dual review and Cohen's kappa, and each included study should receive an appropriate JBI critical appraisal. Future research should validate standardized, match-representative variability metrics against longitudinal injury and performance outcomes and test whether wearable or computer-vision monitoring adds actionable value.

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