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Human Kinetics
CONSENSUS STATEMENT

International Expert Consensus on Warm-Up Protocols for Athletes: A Delphi Study

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Purpose: To present the first international consensus on warm-up in sport. ***Methods:*** Twenty-three experts from 12 countries worldwide participated in a 3-round Delphi process, including an online open asynchronous discussion. A total of 122 initial statements were evaluated across 4 domains: (1) definitions and nomenclature; (2) objectives and structure; (3) exercises, performance enhancement, and mechanisms; and (4) health and injury prevention. ***Results:*** Consensus (≥80% agreement) was achieved for 72 statements (60%). The panel defined the warm-up as a structured and purposeful preparatory intervention aimed at optimizing physiological responses and readiness in both training and competitive settings with a combination of both active and passive strategies. Experts identified a 3-layer model comprising general and specific exercises and conditioning activities, with the latter being voluntary contractions of sufficient volume and intensity to induce postactivation performance enhancement. Athletes' readiness and fatigue can be monitored during warm-up protocols with different tools. The comprehensiveness of a warm-up protocol is a key factor associated with its effectiveness. Warm-ups were recognized as context- and sport-dependent, integrating diverse goals depending on the sport's contextual factors and individual characteristics. While inclusion of some type of exercises in the warm-up may reduce long-term injury risk, as in other periods of the training session, there is no support for acute injury protection. ***Conclusion:*** This consensus confirms that warm-ups are structured, multifactorial interventions integrating active and passive components to enhance readiness for training and competition. This framework serves to inform research design and effective evidence-informed warm-up strategies across sports disciplines.

Keywords: postactivation potentiation, postactivation performance enhancement, injury risk, strength and conditioning, conditioning activities, priming exercises

Any sporting activity is usually preceded by a routine known as a warm-up. The term "warm-up" is related to one of the athletes' objectives, which is increasing muscle temperature; this response has recently been confirmed as one of the main physiological objectives[1] for enhancing subsequent neuromuscular performance. In general, athletes use a warm-up to increase their readiness to train or compete, with the selected protocol commonly tailored to the specific requirements of subsequent activities. In practice, every sport has its own typical warm-up routines, which are often adapted for individual athlete requirements, although some common practices are used across events and sports. A warm-up protocol typically involves the execution of general, submaximal, nonspecific exercises followed by specific, more intense exercises. However, the contextual factors of every sport (eg, time constraints,[2] climatic conditions,[3] facilities,

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team personnel, and available equipment) and their specific physical and physiological demands provide a myriad of protocol designs that make it difficult to identify common structures and objectives. This challenge is further compounded by substantial interindividual and intraindividual variability and personal preferences. In practice, some activities, such as static stretching, are typically performed during warm-up despite limited or even negative effects on performance reported in most cases.[4] Within this contemporary picture, it is necessary to examine the validity and effectiveness of different approaches used in competitive sport to better inform warm-up practices of athletes.

The scientific evidence on warm-up practices and related topics such as postactivation potentiation (PAP) and postactivation performance enhancement (PAPE) is extensive.[5–11] This great interest reflects a general understanding that warm-up protocols are relatively easy to study and widely regarded as an efficient and impactful means to increase athletes' preparedness despite variable effects on performance. In addition, warm-up protocols are also commonly used for other training purposes like injury prevention[12,13] or athlete education.[14] However, despite the wide availability of evidence on warm-up mechanisms,[1,9] designs,[15–17] and performance effects,[18–22] the sports and exercise science literature is conflicting. Further work is required to establish agreed definitions, best practices, and the underlying study designs to better develop, refine, optimize, and implement warm-up protocols for sports, events, and individuals. In this regard, the systematic review by Xu et al[18] recently confirmed that most warm-up literature has inflated the effect size of performance enhancements induced by diverse conditioning activities. This conclusion was based on an assessment that the control conditions for comparisons involving passive resting conditions may have induced a "cooling down" effect. There is also anecdotal evidence of no performance enhancement after a warm-up protocol.[23] Therefore, while extensive and complex, the current scientific evidence on warm-up protocols requires a comprehensive evaluation for the benefit of athletes and coaches.

A scientific consensus regarding definitions, objectives, structure, mechanisms, and exercise selection of warm-up protocols is required. This consensus would stand as a starting point to close the gap between scientific evidence and athletes' real-world practices via better designed, more specific and effective warm-up protocols. By providing a critical summary of what is currently known, this consensus examines key aspects of knowledge translation and dissemination. This work aims to inform research priorities for both observational and experimental research in warm-up protocols. For this purpose, we conducted a comprehensive Delphi survey involving recognized sport science experts on warm-up and related topics.

Methods

Participants

Six core members (Boullosa, Gil-Calvo, Patikas, Xenofondos, Pyne, and Foster) were responsible for conceptualizing the study, identifying and recruiting panelists, preparing the initial statements and the survey for review by panel members in each round, analyzing the scores and comments of panelists, and communicating with panelists when necessary.

Panelists were selected based on their scientific expertise and publication record in warm-up strategies in diverse sports and related topics (eg, PAP, PAPE). In addition, attention was given to ensure geographical and gender diversity, as well as the inclusion of panelists with substantial practical sporting experience. A total of 23 experts agreed to join the expert panel, including 4 core members among them. All participants received a comprehensive document describing the study objectives and methodology, and consent was obtained prior to completion of the survey.

The final panel comprised experts affiliated with institutions from Australia (n = 5), Brazil (n = 3), France (n = 2), Germany (n = 2), Portugal (n = 2), Spain (n = 2), Canada (n = 1), China (n = 1), Cyprus (n = 1), Greece (n = 1), Norway (n = 1), the United Kingdom (n = 1), and the United States (n = 1). To confirm the scientific credentials of the panelists, a search was conducted in the Scopus and PubMed databases on March 4, 2026. This search confirmed that the panelists had published a median of 5 (range: 2–29) full peer-reviewed articles on warm-up related topics and held a median H-index in Scopus of 36 (range: 5–92), reflecting a high level of academic productivity and influence in the field. In addition, most panelists reported practical experience as athletes (n = 17), coaches (n = 13), and/or sport scientists (n = 17), across a wide range of sports and competitive levels, from recreational to international levels, and Olympic and Paralympic sport.

Methodology

A modified Delphi survey was conducted as described previously.[24] For this survey, panel expert evaluation, judgment, phrasing, and scoring were completed independently on each round. Core members prepared an initial document with a list of statements to be scored and evaluated by the panel members. This approach is considered appropriate where basic information is already available within the scientific literature.[25] A 2-option questionnaire was employed in which panelists were asked to indicate their level of agreement with each statement by selecting either agree or disagree. An open-text box was also provided to allow panelists to include comments or justifications for their responses. A Likert-type scale was not used, as a binary response format simplifies the decision-making process and facilitates identification of consensus. In addition, an open discussion phase allowed further refinement of statements with participation of the panelists before the final round.

This study adopted an a priori 80% agreement threshold, meaning a statement was considered to have reached consensus if at least 80% of panelists selected "agree," in line with commonly used criteria.[25,26] Three rounds were performed via online forms (Google LLC). The panelists had a month to try to respond in each round, and all communications were conducted by electronic mail. A deadline extension was required within and between all rounds for 2 main reasons. First, the geographical diversity of the panel resulted in markedly different academic calendars, which created scheduling challenges among countries. Second, some panelists reported that they had manuscripts under review or accepted for publication in scientific journals on topics directly related to the present study. As a result, it was considered appropriate to allow time for publication of these relevant articles and incorporation of the most up-to-date scientific knowledge into the consensus process.

After the first round, statements that received less than 50% agreement were automatically rejected. Statements with 80% or more agreement were accepted as having reached consensus. Those statements with agreement between 50% and less than 80% were retained and included in the second round for further review. Similarly, between the second and third rounds, statements that reached 80% or more of agreement were accepted as having achieved consensus. Statements with agreement levels between 65% and less than 80% were selected for open discussion among all panelists and core members. Statements with less than 65% agreement were rejected and excluded from both the open discussion and the third round. The open discussion was conducted via the Slack platform (Slack Technologies, LLC) to facilitate an asynchronous discussion among panelists and core members across different time zones. For the open discussion, panel members were encouraged to contribute with precise insights and perspectives on the statements under review based on state-of-the-art evidence. The uploading of articles supporting their comments was also encouraged.

The decision made in each round comprised of 6 actions: (1) *Modify*—when a statement was substantially modified, either by suggestion of a panel member or to meet new evidence; (2) *Review*—when additional information or literature was provided to panelists to enhance the level of evidence and support informed decision making; (3) *Divide*—when a statement was divided into 2 different statements; (4) *Combine*—when 2 statements were merged into a single one due to overlapping content; (5) *Reject*—when a statement did not reach at least 50% agreement in the first round and 65% in the second round; and (6) *Accept*—when a statement met the criteria (≥80% agreement) and was accepted to be part of the consensus.

Results

A flowchart (see Figure 1) illustrates the process conducted throughout the study. The core members initially proposed a total of 122 statements, distributed across 4 themes: (1) *definitions and nomenclature*; (2) *objectives and structure*; (3) *exercises, performance enhancement, and mechanisms*; and (4) *health and injury prevention.* After the open discussions, 1 statement was divided into 2, and 4 statements were merged into 2, resulting in a final total of 121 statements for evaluation at the end of the process. Then, at the end of the 3-round Delphi process, a total of 72 (60%) statements were accepted, while 49 (40%) were rejected (see Supplementary Materials [available online]).

The first round of block 1, *definitions and nomenclature,* included a total of 8 accepted statements (47%), while 4 statements (24%) were included in the second round for further review, and 5 statements (29%) were rejected. Following the second round and the open discussion phase, 1 additional statement was accepted,

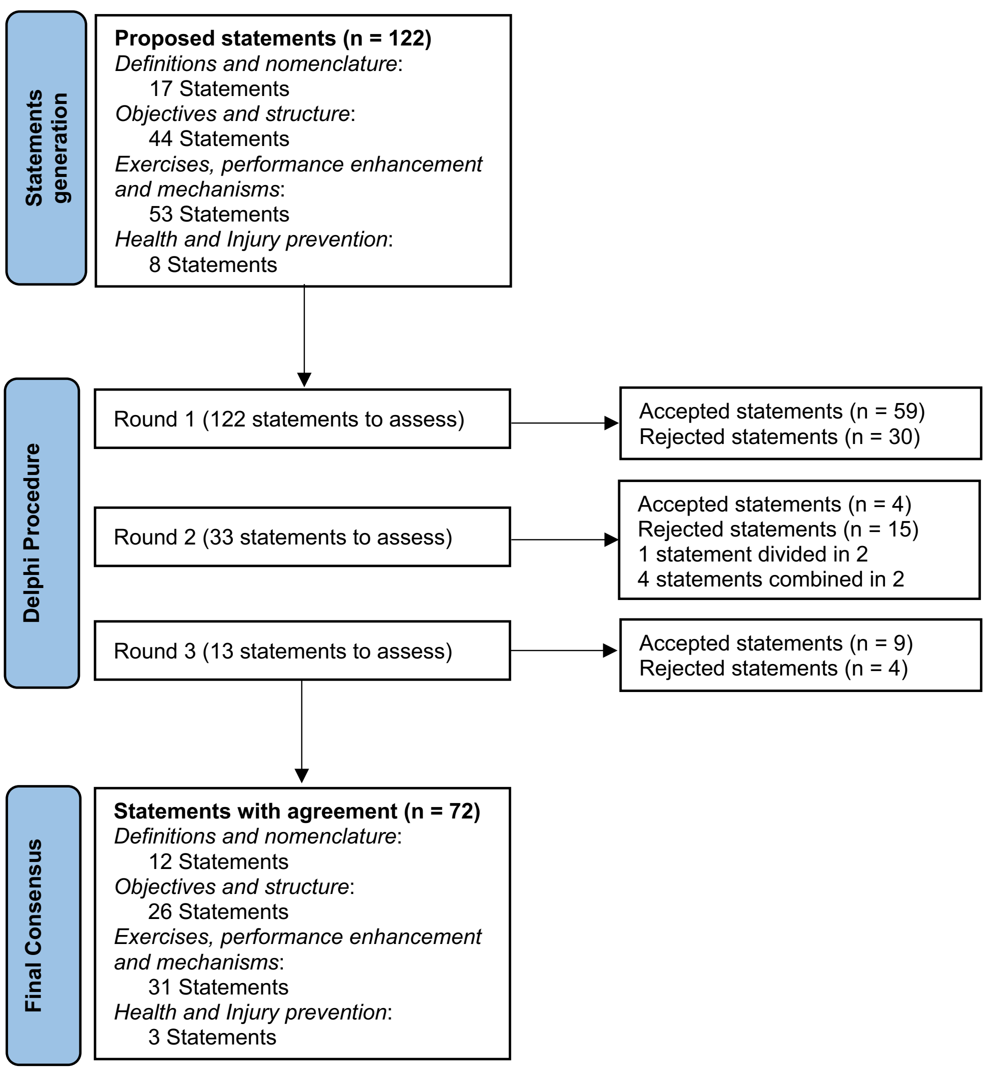

Figure 1 — Flowchart of the process.

1 was rejected, 1 was proposed to be divided into 2 new statements, and 1 was marked for modification. After the third round, the remaining 3 statements were accepted. In total, 18 statements were assessed and 12 were accepted (68%; see Table 1).

The first round of block 2, *objectives and structure,* included a total of 22 accepted statements (50%), while 11 statements (25%) were included in the second round for further review, and 11 statements (25%) were rejected. Following the second round and the open discussion phase, 2 additional statements were accepted, 5 were rejected, and 4 statements were proposed to be combined into 2 new statements. After the third round, the remaining 2 statements were accepted. In total, 42 statements were assessed and 26 were accepted (62%; see Table 2).

The first round of block 3, *exercises, performance enhancement, and mechanisms,* included a total of 27 accepted statements (51%), while 16 statements (30%) were included in the second round for further review, and 10 statements (19%) were rejected. Following the second round and the open discussion phase, 1 additional statement was accepted, 9 were rejected, and 6 were reformulated for inclusion in the third round. After the third round, 3 statements were accepted and 3 were rejected. In total, 53 statements were assessed and 31 were accepted (58%; see Table 3).

The first round of block 4, *health and injury prevention,* included a total of 2 accepted statements (25%), while 2 statements (25%) were included in the second round for further review, and 4 statements (50%) were rejected. Following the second round and

Table 1 Statements Accepted Through Panelists' Evaluations Across the 3 Rounds, Along With Core Panel Decisions for Each Statement in Block 1: Definitions and Nomenclature

		Round 1 (from September 10, 2024 to October 10, 2024)			Round 2 (from January 20, 2025 to February 20, 2025)			Round 3 (from June 10, 2025 to July 10, 2025)		
Statement		A (n)	D (n)	Decision	A (n)	D (n)	Decision	A (n)	D (n)	Decision
1	Warm-up is a protocol designed to increase body temperature.	22	1	Accept						
2	Warm-up is a protocol designed to increase metabolism.	21	2	Accept						
3	Warm-up is a protocol designed to increase readiness.	22	1	Accept						
4	Warm-up is a protocol used by athletes before training sessions and competitions to prepare themselves for subsequent activities.	23	0	Accept						
5	Warm-up is a protocol designed to prepare athletes for subsequent activities in any context.	15	8	Review	19	4	Accept			
6	A competitive warm-up protocol is primarily aimed at enhancing performance.	22	1	Accept						
7	A training warm-up protocol targets preparedness for the specific session objectives.	22	1	Accept						
8	Re-warm up is a protocol designed to re-activate athletes after a first warm-up protocol performed some time (minutes or hours) earlier in the same day.	22	1	Accept						
9	Priming exercises are included in the warm-up protocol to specifically enhance performance capacity.	19	4	Accept						
10[a]	Priming exercises are included in a first warm-up protocol to enhance performance in subsequent activities during the same day.	16	6	Review	12	11	Divide			
11[b]	Priming exercises are performed typically several hours before a session or competition on the previous or same day to enhance performance.	—	—	—	—	—	—	20	3	Accept
12[b]	Priming exercises are designed to benefit from delayed effects in a subsequent session or competition, while re-warm-up protocols are designed to benefit from the short-term acute effects of a previous warm-up.	—	—	—	—	—	—	22	1	Accept
13	Conditioning activities are voluntary actions/contractions of sufficient intensity and volume to induce acute increases in force, power, and/or endurance performance.	14	8	Review	16	7	Modify	23	0	Accept

Abbreviations: A, agree; D, disagree.
[a]Statement that was subsequently divided into 2 as a result of open expert discussions. [b]Statements resulting from the division of the previous statement after open expert discussions.

Table 2 Statements Accepted Through Panelists' Evaluations Across the 3 Rounds, Along With Core Panel Decisions for Each Statement in Block 2: Objectives and Structure

Statement		Round 1 (from September 10, 2024 to October 10, 2024)			Round 2 (from January 20, 2025 to February 20, 2025)			Round 3 (from June 10, 2025 to July 10, 2025)		
		A (n)	D (n)	Decision	A (n)	D (n)	Decision	A (n)	D (n)	Decision
14	Warm-up protocols during training are designed to prepare athletes for the main objectives of the session and can include additional contents and objectives related to periodization.	21	2	Accept						
15	Warm-up protocols for competitions are mainly designed to prepare athletes to achieve the maximum possible performance.	21	2	Accept						
16	The objective of any warm-up protocol is to physically prepare the athletes for subsequent activities.	20	3	Accept						
17	Warm-up is not restricted to prepare athletes for subsequent activities but also developing other contents and objectives (eg, pedagogical, motivational, injury prevention, etc).	21	2	Accept						
18	Warm-up protocols can be used to monitor readiness and fatigue of athletes to inform decisions on the main exercises of the training session.	19	4	Accept						
19	Warm-up protocols could include general and specific warm-up exercises.	23	0	Accept						
20[a]	General warm-up exercises should be predominantly aerobic, continuous, and submaximal in nature with sufficient duration and intensity to increase body temperature and metabolism.	12	11	Review	16	7	Combine			
21[a]	General warm-up exercises can be any activity of sufficient duration and intensity to increase body temperature and metabolism.	15	8	Review	15	8	Combine			
22[b]	General warm-up exercises should be predominantly aerobic, continuous and/or intermittent sport-related activities with sufficient duration and intensity to increase temperature and metabolism of the target muscles.	—	—	—	—	—	—	21	2	Accept
23	Specific warm-up exercises should be designed to physically prepare for subsequent activities.	22	1	Accept						
24	Specific warm-up exercises should be designed to technically prepare for subsequent activities.	21	2	Accept						
25	Specific warm-up exercises should be designed to psycho-logically prepare for subsequent activities.	19	4	Accept						
26	Specific warm-up protocols should be designed to prepare the athletes for subsequent activities.	23	0	Accept						
27	Contextual factors influencing warm-up protocol design include weather conditions (eg, heat, cold, rain, etc), time and space constraints, and availability of equipment and facilities among others.	22	1	Accept						
28	The comprehensiveness of a warm-up protocol is enhanced by the increased number and combination of several general and specific exercises aiming to enhance the different facets of preparedness.	18	5	Review	19	4	Accept			
29[a]	A short warm-up protocol lasts ≤5 minutes and a long warm-up protocol lasts ≥20 minutes.	11	10	Review	18	5	Combine			
30[a]	The typical duration of a warm-up protocol for most sports is ≥20 minutes.	14	9	Review	19	4	Combine			
31[b]	A short warm-up typically lasts ≤5 minutes, while a long warm-up can exceed ~20 minutes. Both have varied combinations of work-to-rest ratios and levels of comprehensiveness.	—	—	—	—	—	—	20	3	Accept
32	The duration of warm-up protocols depends on the sport-specific demands, athletes' characteristics, and contextual factors.	23	0	Accept						

(continued)

Table 2 *(continued)*

Statement		Round 1 (from September 10, 2024 to October 10, 2024) A (n)	D (n)	Decision	Round 2 (from January 20, 2025 to February 20, 2025) A (n)	D (n)	Decision	Round 3 (from June 10, 2025 to July 10, 2025) A (n)	D (n)	Decision
33	The duration of a warm-up protocol depends on the other loading characteristics (ie, intensity and density) of the different exercises included.	22	1	Accept						
34	The duration of a warm-up protocol depends on the sport-specific demands.	23	0	Accept						
35	The duration of a warm-up protocol depends on athlete's characteristics.	19	4	Accept						
36	The duration of a warm-up protocol depends on contextual factors.	23	0	Accept						
37	The structure of warm-up protocols depends on the sport-specific demands.	23	0	Accept						
38	The structure of warm-up protocols depends on athlete's characteristics.	21	2	Accept						
39	The structure of warm-up protocols depends on the contextual factors.	20	3	Accept						
40	The objectives and structure of warm-up protocols are significantly different among power demanding sports, endurance sports, mixed sports, aesthetic sports, and precision sports.	20	3	Accept						
41	It is possible to design warm-up protocols following standardized conditions with generalizable effects for most athletes of the same sport.	17	6	Review	19	4	Accept			
42	There is substantial variability in responses to standardized warm-up protocols; therefore, any warm-up protocol should be individualized according to training background and athlete's characteristics.	19	4	Accept						
43	A re-warm-up protocol is shorter than the main warm-up protocol performed, given there are some delayed effects of the first protocol.	22	1	Accept						

Abbreviations: A, agree; D, disagree.
[a]Statements that were combined into a single one following open discussions among the experts. [b]Statement obtained by merging the 2 previous statements following open discussions among the experts. In statement 33, density refers to the work-to-rest ratio.

the open discussion phase, no additional statements were accepted, and 2 were reformulated for inclusion in the third round. After the third round, 1 statement was accepted and 1 was rejected. In total, 8 statements were assessed and 3 were accepted (38%; see Table 4).

Discussion

Following the Delphi process, a majority of the statements proposed (ie, 72 out of 121, 60%) were finally accepted with a stringent cutoff of ≥80% agreement. For every block of topics, a similar trend of higher acceptance (>50%) was observed except for health and injury prevention statements, where only 3 out of 8 were accepted (38%). These results confirm the limited scientific consensus regarding different aspects of warm-up practices by athletes, while creating the foundations from which practitioners, sport researchers, and coaches should collaborate to better inform field practices.

Definition and Nomenclature

The consensus achieved within block 1 provides a solid conceptual foundation for interpreting warm-up protocols across both research and applied settings. The experts reached agreement on 13 out of 17 proposed statements, reinforcing that warm-up should not be conceived as a generic and unspecified preparatory routine, but rather as a structured intervention with specific physiological and psychological objectives. The accepted statements emphasized 3 central and complementary perspectives, with warm-up protocols designed to (1) stimulate metabolism, (2) increase body and muscle temperature, and (3) enhance readiness. These elements highlight the multidimensional nature of a warm-up, extending beyond a simple thermal effect and incorporating neuromuscular, metabolic, and cognitive processes that collectively enhance readiness for training or competition.[14,27] The consensus also distinguished between competitive warm-ups, primarily aimed at maximizing performance, and training warm-ups, which are more closely aligned with the primary objectives of the training session. This distinction is crucial, as it provides coaches and sport scientists with a framework to tailor warm-up strategies according to the specific demands of the sport and training load management.[14,28]

Recognition of a re-warm-up protocol serving as a specific intervention to restore physiological and physical activation after an initial warm-up reflects practical challenges frequently observed in competition scenarios (eg, swimming), such as long delays between the warm-up and matches or successive competitive starts (eg, within-day rounds).[29,30] Similarly, acknowledgment of priming

Table 3 Statements Accepted Through Panelists' Evaluations Across the 3 Rounds, Along With Core Panel Decisions for Each Statement in Block 3: Exercises, Performance Enhancement, and Mechanisms

Statement		Round 1 (from October 20, 2024 to November 20, 2024) A (n)	D (n)	Decision	Round 2 (from January 20, 2025 to February 20, 2025) A (n)	D (n)	Decision	Round 3 (from June 10, 2025 to July 10, 2025) A (n)	D (n)	Decision
44	Warm-up protocols could include both active (eg, running, cycling) and passive techniques (eg, heating) or exercises (eg, passive stretching).	21	2	Accept						
45	The use of exercises for which athletes are well familiar with reduces the learning effects.	20	3	Accept						
46	The use of exercises for which athletes are well adapted to reduces the levels of muscle soreness.	20	3	Accept						
47	There is not a single physiological adaptation that is the goal of a warm-up as most protocols should stimulate to varying extents, a variety of acute adaptations (eg, cardiorespiratory, neuromuscular, etc).	14	9	Review	16	7	Modify	23	0	Accept
48	A specific physiological effect (eg, metabolic vs neuromuscular) can be prioritized during a warm-up protocol depending on the demands of subsequent activities.	23	0	Accept						
49	The physiological effects of warm-up protocols are time dependent in the sense that they are lost progressively with no activity after the end of the protocol.	23	0	Accept						
50	The loss of physiological effects associated with reduction of body temperature after the end of any warm-up protocol can be attenuated with the use of passive heating techniques.	19	4	Accept						
51	The physiological effects of warm-up protocols are time dependent in the sense that the exercises included and their loads affect the timing of the desired effects.	22	1	Accept						
52	One purported effect of a warm-up including high-intensity cardiorespiratory exercises, from short (eg, 30 s) very high-intensity bouts to longer less intense bouts of a few minutes, is to accelerate the oxygen kinetics following the start of the subsequent activity	13	8	Review	16	7	Modify	23	0	Accept
53	PAP can increase the rate of force or torque development.	23	0	Accept						
54	Brief near maximum or maximal voluntary contractions promote PAP.	22	1	Accept						
55	The muscle phenotype associated with the predominance of fast- vs slow-twitch fibers determines the effect of voluntary contractions of varied intensities as a result of a positive PAP/fatigue balance.	18	5	Review	19	3	Accept			
56	PAPE refers to enhancements in exercise performance (eg, speed, power, endurance) that can be attributed to conditioning activities included in a warm-up protocol.	18	5	Review	18	5	Modify	20	1	Accept
57	PAP may influence PAPE.	20	3	Accept						
58	PAP and PAPE may share some mechanisms (eg, modification of muscle temperature).	21	2	Accept						
59	PAPE is the result of the positive balance between the factors promoting performance enhancement and acute fatigue after any warm-up protocol.	19	4	Accept						
60	The maximum PAPE effect after any warm-up protocol varies in timing and magnitude and is highly individualized.	21	2	Accept						
61	PAPE magnitude is influenced by athletes' training background and performance level.	23	0	Accept						
62	PAPE magnitude is influenced by exercises loading (ie, volume, intensity, and recovery) during the warm-up protocol	23	0	Accept						
63	PAPE magnitude may be associated with a reduced exercise density (ie, work-to-rest ratio) during the warm-up protocol.	22	1	Accept						

(continued)

Table 3 (continued)

Statement		Round 1 (from October 20, 2024 to November 20, 2024)			Round 2 (from January 20, 2025 to February 20, 2025)			Round 3 (from June 10, 2025 to July 10, 2025)		
		A (n)	D (n)	Decision	A (n)	D (n)	Decision	A (n)	D (n)	Decision
64	PAPE magnitude is influenced by the sequence of exercises during the warm-up protocol.	20	2	Accept						
65	PAPE timing is influenced by athletes' training background and performance level.	21	2	Accept						
66	PAPE timing is influenced by exercises loading (ie, volume, intensity, and recovery) during the warm-up protocol.	22	1	Accept						
67	PAPE timing is influenced by the sequence of exercises during the warm-up protocol.	19	4	Accept						
68	There are circadian influences on the effects of warm-up protocols.	20	1	Accept						
69	The exercises and loading of warm-up protocols should vary depending on the age of the athletes.	21	2	Accept						
70	Excessive hot humid conditions can negatively affect the warm-up effects when yielding a markedly higher central temperature.	22	1	Accept						
71	Excessive cold can negatively affect the warm-up effects by limiting the increase in body temperature.	21	2	Accept						
72	In general, dynamic stretching exercises are preferred to static stretching exercises during warm-up protocols.	21	2	Accept						
73	Static stretching exercises in the warm-up can be appropriate for those athletes requiring high levels of flexibility.	20	3	Accept						
74	The negative effect of static stretching exercises on muscle stiffness can be mitigated with the performance of selected activation exercises.	21	2	Accept						

Abbreviations: A, agree; D, disagree; PAP, postactivation potentiation; PAPE, postactivation performance enhancement.

Table 4 Statements Accepted Through Panelists' Evaluations Across the 3 Rounds, Along With Core Panel Decisions for Each Statement in Block 4: Health and Injury Prevention

Statement		Round 1 (from October 20, 2024 to November 20, 2024)			Round 2 (from January 20, 2025 to February 20, 2025)			Round 3 (from June 10, 2025 to July 10, 2025)		
		A (n)	D (n)	Decision	A (n)	D (n)	Decision	A (n)	D (n)	Decision
75	The inclusion of predominantly aerobic exercises (ie, sub-maximal exercises involving large muscle groups) of sufficient volume and intensity in the warm-up reduces cardiovascular stress and risk of ischemia.	18	5	Review	17	6	Modify	22	1	Accept
76	It is possible to chronically reduce the risk of injuries when including preventive exercises (eg, strength, balance, etc) in the warm-up protocol.	19	4	Accept						
77	It is possible to chronically reduce the risk of injuries when including preventive exercises (eg, strength, balance, etc) in the warm-up protocol as well in other parts of the training session.	23	0	Accept						

Abbreviations: A, agree; D, disagree.

exercises as a distinct preparatory strategy, often conducted hours or even days before competition to induce delayed effects, underscores the need to differentiate them from re-warm-ups that target acute and transient responses.[31,32] Within the present consensus, priming exercises were therefore distinguished from warm-up activities by their temporal separation from the subsequent task, although some objectives (eg, performance enhancement or readiness) may overlap under specific conditions. By consolidating these definitions, the panel provided terminology that clarifies terms often used interchangeably in both scientific literature and practice, thereby promoting clarity and consistency. Importantly, the consensus about definitions and nomenclature does not bind the warm-up to specific forms of exercise (ie, it is not a reflection on what tasks can or should be considered necessary during a warm-up).

The inclusion of conditioning activities as voluntary actions or contractions of sufficient intensity and volume to induce acute increases in force, power, or endurance was another important advancement in the consensus process. This definition links warm-up not only to general preparatory tasks but also to targeted neuromuscular strategies capable of eliciting PAP or PAPE.[7–10,33–35] Within this framework, preparatory exercises previously described in the literature as "priming" for accelerating oxygen uptake kinetics can be interpreted as conditioning activities, as they aim to acutely enhance endurance performance when included in a warm-up protocol. Evidently, what constitutes sufficient intensity and volume will likely vary depending on sport, context, training phase, and individual features, among other factors. By defining conditioning activities as a specific subset within the broader warm-up framework, the consensus helps distinguish between exercises whose primary role is a more global physiological activation (eg, aerobic movements that increase body temperature and cardiovascular responsiveness) and those specifically designed to acutely enhance performance potential.[7,9,34,36] This clarity was deemed essential for developing warm-up protocols that are both evidence-informed[37] and adaptable to sport-specific demands. In practice, the distinction between general, specific, and conditioning activities provides a 3-layer model of warm-up design, where each component plays a distinct role, while contributing synergistically to performance readiness.[9,18,34] From a research perspective, this framework offers a standardized approach that can improve methodological rigor and precision, facilitating comparability across studies investigating warm-up mechanisms and outcomes. Whether practitioners decide to include all 3 components in a single warm-up or not is a decision that will rely on many different factors, such as the goals for a specific training session or match, general state of fitness and fatigue, and the intensity and duration of the training session.

Although most of the proposed statements in block 1 were accepted, 6 statements were rejected, highlighting the strengths and consistency of the consensus process. For example, the panel dismissed the idea that training and competitive warm-ups are equivalent, acknowledging their fundamental differences in objectives and structure.[14,38] Similarly, statements equating priming and conditioning activities, or suggesting that priming exercises universally enhance oxygen uptake kinetics, were rejected due to the risk of oversimplification. These exclusions highlight the panel's commitment to precision and scientific validity, ensuring that only concepts with strong theoretical and practical grounding were adopted. Importantly, rejecting overly broad or redundant definitions prevents conceptual overlap and preserves the distinctiveness of each term, which is essential for advancing applied recommendations and future investigations. Taken together, the outcomes of block 1 yielded definitions and nomenclature for establishing a comprehensive and technically rigorous foundation that serves as a reference point for practitioners, coaches, and researchers. This foundation also identifies areas where further empirical work is needed to refine and validate the operational boundaries of warm-up terminology.

Objectives and Structure

The consensus process resulted in 26 accepted statements related to block 2, reflecting broad agreement among experts on the multifaceted role of warm-ups, while also highlighting the need for contextual and sport-specific practices. Collectively, these statements indicate that warm-ups are not rigid but rather a flexible framework comprising immediate preparatory routines and strategic components of broader training and competition plans. The statements encompass diverse objectives, structures, and applications shaped by physiological mechanisms, contextual realities, and sport-specific demands. While this consensus represents a meaningful step toward a more systematic, effective and evidence-informed approach to warm-ups, it also reveals persistent tensions between comprehensiveness and efficiency, standardization and individualization, and scientific rationale and applied feasibility that collectively must be addressed to better connect scientific evidence with field applications.

The panel agreed that the primary objective of any warm-up is to physically prepare athletes for subsequent activities. However, the panel strongly supported the broader functional role of warm-ups to address technical, psychological, pedagogical, and injury-prevention goals. This broader perspective is consistent with previous literature suggesting that warm-ups can serve as a platform for enhancing both immediate readiness and long-term development. For instance, Bishop[5] highlighted that warm-ups can enhance muscle temperature, nerve conduction velocity, and oxygen uptake kinetics, thereby facilitating performance readiness. Yet, beyond acute physiological benefits, warm-ups may also foster cognitive, technical, and psychological preparedness, which are crucial in sports like precision and aesthetic sports where focus and arousal regulation may be paramount.[14]

Importantly, the consensus distinguished between training and competition contexts. Training warm-ups can serve to integrate pedagogical or development content aligned with skill acquisition and periodization goals,[14] while competition warm-ups are more narrowly focused on optimizing subsequent performance.[39] This distinction supports the idea that warm-ups should be tailored not only to the sport but also to the specific demands of the session or event.

Another notable outcome was recognition of warm-ups as a practical protocol for monitoring athlete readiness and fatigue. This premise aligns with emerging practices in high-performance sports (eg, quantifying movement velocity, jump performance, or perceived exertion), where warm-up responses are used as noninvasive indicators of cardiovascular and neuromuscular status to inform training decisions and adjust workloads in real time.[40–42] This approach, which involves dual preparatory and diagnostic functions, strengthens the relevance of warm-ups in modern high-performance environments. However, concerns remain about the reliability and ecological validity of such measures, especially under competitive constraints where time is limited.

The consensus confirmed the importance of structuring warm-ups into general and specific components, although the inclusion of both components may vary depending on context and goals. General warm-up components were described as predominantly aerobic, continuous or intermittent, and of sufficient intensity and duration to increase body temperature and metabolism, thereby "raising" the system in line with the RAMP model (Raise, Activate, Mobilize, Potentiate).[43] Specific warm-up components are designed to prepare athletes for the physical, technical, tactical, and psychological demands of the upcoming activity.

This structured progression reflects a balance between mechanistic rationale and applied practice. For example, Behm et al[44] reported that dynamic warm-up activities enhance neuromuscular function and reduce the negative effects of prolonged static stretching (ie, >60 s per muscle group), supporting their inclusion in specific warm-up sections. Conversely, the consensus acknowledged that comprehensiveness, not duration alone, is a key consideration. While warm-ups typically last 15 to 20 minutes, their effectiveness depends more on exercise selection, sequencing, and load management than on a fixed timeframe. This view aligns with

McGowan et al[45] who showed that short but well-targeted priming or re-warm-up strategies may be sufficient in high-performance settings. Nevertheless, a potential concern is the risk of excessive loading during warm-ups, which could induce fatigue and compromise performance.[46] As highlighted in previous studies,[30,47] the balance between readiness and fatigue is highly individualized and can be affected by fitness level, loading, age, and sex.[34] These factors underscore the need for careful design, following scientific evidence and practical experience, and familiarization.

A major theme in the consensus was the influence of contextual and individual factors on warm-up design, with environmental conditions (eg, temperature, humidity, rainfall and wind, space, equipment, ground, or court surfaces), sport-specific facilities, and athletes' characteristics (eg, age, training background, fatigue) identified as key determinants of both structure and duration. Although the panel agreed that standardized warm-ups may be appropriate within a single sport, they also emphasized the need for individualization, given the substantial variability in athlete responses.[39,45,48] This flexible approach reflects the balance between logistical feasibility and performance optimization, particularly in competitive contexts where time, space, and equipment are limited. In applied practice, hybrid approaches may offer the most effective solution, establishing a standardized baseline protocol for consistency, while allowing individualized modifications based on athlete preference, readiness monitoring, and fatigue status.

Finally, the Delphi panel reached strong agreement that the objectives and structure of warm-up protocols differ substantially across sport types, including power, endurance, mixed, aesthetic, and precision sports. For example, power sports (eg, sprinting, weightlifting) may prioritize neuromuscular activation through explosive, high-intensity activities,[48] while endurance sports typically focus on metabolic readiness and oxygen transport and utilization. Aesthetic and precision sports, in turn, may require greater emphasis on psychological and technical readiness.

These differences support the development of sport-specific warm-up models, as proposed in recent studies.[21,39] However, a potential limitation is that such models, if applied rigidly, risk neglecting interindividual variability. Instead, warm-up design should remain adaptable, with sport-specific templates serving as a guide rather than rigid and prescriptive.

Exercises, Performance Enhancement, and Mechanisms

The third block presented most of the initial statements and achieved a modest 58% acceptance rate, with 31 of 53 statements accepted. This outcome indicates that, despite the wide body of evidence on these topics, several issues require further examination and resolution through the development of new approaches in warm-up research.

Based on the accepted statements, and consistent with previous advice,[6] warm-up protocols may include both active and passive interventions, where passive interventions include heating and passive muscle stretching. Regarding active warm-up, it was agreed that there may be no single goal and the protocol should stimulate, to varying extents, a variety of acute neuromuscular, cardiorespiratory, and metabolic responses. However, a specific physiological effect can be prioritized during a warm-up protocol. For example, high-intensity cardiorespiratory exercises, from short (eg, 30 s) high-intensity bouts to longer, less intense bouts of a few minutes, may accelerate oxygen uptake kinetics following the start of the subsequent activity, which may benefit endurance performance.[49–51] Alternatively, brief high-intensity muscle contractions can improve peak power or movement speed in tasks performed shortly afterward.[9,52,53] It was also agreed that including familiar exercises should permit athletes to better perform the required warm-up tasks, as well as reduce the risk of any subsequent muscle soreness but not fatigue. In this regard, the use of exercises during warm-up that are similar to the subsequent training or competition tasks may also contribute to performance enhancement via acute practice effects.[8,9] However, the kinetic or kinematic similarity between conditioning activities and subsequent tasks is not mandatory.[7] These aspects may be important considerations in exercise selection.

Consensus was reached that high-intensity conditioning stimuli should be included in most warm-ups. After 3 rounds, it was agreed that the term "postactivation performance enhancement" describes the enhancement in exercise performance (eg, speed, power, endurance) that can be attributed to conditioning activities included in a warm-up protocol. This construct differs from PAP, which refers to the enhancement of muscle force (eg, rate of force development) for a known activation, which is usually tested using neuromuscular electrical stimulation of a muscle (ie, evoked muscle contraction) after a voluntary activation of the muscle.[8,9,16] Consensus was reached in the first round that "classic" PAP can increase muscle rate of force development and contribute to PAPE. It was also agreed that PAP effects may depend on individual characteristics, such as the proportion of fast- and slow-twitch fibers, and its magnitude may be affected by factors that also contribute to PAPE, such as muscle temperature.

Consensus was reached in the first round that PAPE results from a positive balance between performance enhancement and acute fatigue (although one should be mindful of motor pattern interference effects, which may be mistaken as fatigue effects[9]). It was also agreed that the magnitude and timing of PAPE differ between individuals. It was agreed that this variability in both the magnitude and timing of PAPE is influenced by the athlete's training background and performance level (may be higher in better-trained or high-level athletes), the volume, intensity, and recovery characteristics (including work-to-rest ratio) of the conditioning activity, and the sequence of exercises during the warm-up protocol.[9,18] Nonetheless, an unresolved question is which types of conditioning activities can consistently yield meaningful performance enhancements when completed after an otherwise comprehensive warm-up that includes enough high-intensity task-specific practice.[18] It was noted that most of the research has tested conditioning activities without or after minimal warm-up. Several additional issues also surround research study design, which both biases outcomes to reveal greater effects than would be detected if an appropriate study design had been used (including properly instigated control testing, participant and experimenter bias, and protocol familiarization), and rarely offers insight into the effects of conditioning activities used as part of a comprehensive warm-up protocol.[8,9,16,18] Thus, identification of specific conditioning activities that best elicit a positive response and the factors associated with their effectiveness (eg, magnitude, time course, cohort-specific, and individual benefits, etc) is essential. Regardless, the use of conditioning activities within a warm-up to evoke PAPE is recommended, with due consideration of their individual effects.

An important consideration within warm-ups is the temporal nature of acute neuromuscular, cardiorespiratory, and metabolic alterations.[9,54] Consensus was reached in the first round that warm-up effects are circadian in nature, and that the physiological effects of warm-up protocols are time dependent and progressively lost with no activity after the end of the protocol. The magnitude and timing of this loss are affected by the load and strongly associated with the reversibility of acute alterations (eg, motor unit recruitment patterns, intracellular oxygen utilization, muscle temperature). While both active and passive methods to increase temperature can be effective for improving muscular performance,[1,5,6] inclusion of active warm-ups may also provide an additional acute practice effects.[1,45] Some warm-up effects may be at least partly produced or maintained by passive heating without requiring ongoing, potentially fatiguing, exercise. Nonetheless, excessive hot or humid conditions can negatively affect the warm-up effects by yielding a markedly higher core temperature. Similarly, cold conditions can negatively affect the warm-up effects by limiting the increase in muscle temperature.[1,6] Thus, warm-up exercises, intensities, and durations may need to vary depending on the underlying environmental conditions.

Both active and passive techniques and exercises can be used in a warm-up protocol to activate certain physiological mechanisms, but emphasis should be placed on those related to the demands of subsequent activities. For instance, in endurance sports, one of the purported benefits of a warm-up that includes high-intensity cardiorespiratory exercises, from short (eg, 30 s), very high-intensity bouts to longer, less intense bouts of a few minutes, is to accelerate oxygen uptake kinetics at the start of the subsequent activity.[50] Alternatively, PAPE effects can be improved through increases in muscle temperature and activation (among other mechanisms) that can be evoked by higher-intensity warm-up tasks, including brief, maximal-effort conditioning activities.[18] These acute physiological responses are time-dependent in the sense that the exercises included, and their load, duration, and intensity, affect the timing of desired effects, while they are lost progressively without continued activity after the end of the protocol. Maintenance of some responses requires ongoing exercise, although increased muscle temperature may be maintained using passive techniques.[1]

Within the context of comprehensive warm-ups, another issue of concern relates to the appropriateness of different forms of muscle stretching. It was agreed that dynamic stretching exercises are generally preferred to static stretching exercises during warm-up protocols, although static stretching can be appropriate for those athletes requiring high levels of flexibility. It should be noted that most recent systematic reviews confirm that static stretching does not significantly affect explosive strength, including rate of force development, running economy, or performance in tasks such as jumping or sprinting, although longer stretch durations (> 60 s per muscle group) tend to negatively affect maximum strength.[55,56] The negative effect of static stretching exercises can be mitigated with the performance of selected activation exercises. Decisions around the use of dynamic and static stretching during the warm-up should therefore be made based on these considerations and underlying complexity.

Health and Injury Prevention

The present scientific consensus agreed, in the last block, that it is possible to reduce the long-term risk of injuries when including preventive exercises (eg, strength, balance) in the warm-up protocol and throughout other parts of the training session. Therefore, whether this protection results from a warm-up effect or from the repetition of a structured training program is presently unclear. In contrast, there was no consensus for attributing an acute effect of warm-up protocols for reducing the risk of injuries, in agreement with the recent assertion by Afonso et al[57] In addition, it was agreed the inclusion of aerobic exercise in the warm-up may provide additional cardiovascular protection through reduced cardiovascular stress and ischemia, which is relevant for athletes exposed to high cardiovascular load or heightened risk of cardiovascular medical conditions.

There is debate in the literature about whether all components of a warm-up protocol contribute to injury prevention, especially stretching exercises that are often included. In this consensus, we have focused on warm-up as a whole and not specifically on stretching exercises. Readers are directed to state-of-the-art evidence examining the effects of stretching exercises on injury risk. Several systematic reviews[44,58–69] and a recent international consensus[70] present a consistent pattern of outcomes: (1) there is no effect of stretching on overall injury risk, and (2) some reviews report a protective effect of stretching on muscle injuries. However, inspection of the individual studies commonly reveals a parallel increase in other injury risks (eg, joint, bone). More recently, the largest systematic review to date (>9000 participants) performed ~40 different meta-analytical treatments, all of which showed no effect of stretching on injury risk.[71] It is apparent that all existing studies refer to the *chronic* effects of stretching on injury risk (up to a maximum of 24 wk of intervention, with total stretching duration ranging from 6 min to 42 h). This is insufficient information to ascertain whether stretching *acutely* affects injury risk (eg, as part of a warm-up protocol).

Future Perspectives on Unaccepted Statements

Classification and Role of Warm-Up Exercises

General and specific exercises are distinct phases of a warm-up routine[72] and their implementation may depend on the overall aims. However, it remains unclear how these exercises should be integrated within a warm-up routine as well as how they independently or synergistically contribute to technical readiness. While the meaning of "priming exercises" appears mostly clear, the term "conditioning activities" encompasses diverse exercises that should be further defined depending on the targeted physical capacity.[73] In addition, it should be agreed whether the RAMP components better fit within this model.

Multiple Objectives and Mechanisms of Warm-Up

Depending on the context, a warm-up may emphasize the physical, technical, tactical, or psychological preparation of the athlete. Warm-up can also serve additional purposes, such as meeting pedagogical objectives.[14] However, the detailed structure should be individualized according to athlete and team environments, training plans, and competition goals.[14,18] Accordingly, a warm-up might affect various physiological mechanisms by activating both the anaerobic and aerobic systems.[5,6] In contrast, the mechanisms underlying the effectiveness of priming exercises remain unclear and warrant further investigation, as these interventions differ from the acute metabolic responses typically associated with warm-up protocols.

Diversity of Warm-Up Duration

Investigators have suggested that a warm-up should last longer than 10 minutes.[5,6] However, no optimal duration is proposed since the length of warm-up can vary widely depending on contextual factors and individual characteristics.[14] Re-warm-up scenarios (eg, halftime, quarters, double-sessions) raise the need to balance fatigue avoidance and optimal preparedness.[30] The interaction between warm-up duration and its comprehensiveness is an area to be further explored.

Differences Across Cohorts and Populations

Athletes from different sports, maturity levels, age groups, and sexes may require distinct warm-up routines and structures.[47] However, current evidence is insufficient to determine their generalizability or specificity, which warrants further exploration.

Familiar Versus Novel Exercises

While it seems logical to focus on exercises used on a regular basis, it remains to be determined whether warm-ups should also incorporate some novel exercises after a short familiarization in some cases. The practical advantages and disadvantages of both approaches need further evaluation.[14]

Definitions and Mechanisms of PAP and PAPE

No full consensus has been reached regarding the mechanisms and interrelations of PAP and PAPE,[7,9,10,18,36,74] although it has been accepted that they share some common mechanisms and influence. Despite the abundance of studies, additional work and a clearer understanding of physiological and mechanical phenomena are still required.

Effectiveness of Adjunct Methods

Depending on the training or competition context, the inclusion of ergogenic aids (eg, caffeine, sodium bicarbonate),[75,76] motor imagery,[77] mental rehearsal,[78] or music[79] in warm-up protocols could be beneficial but requires further investigation to determine their effectiveness and applicability in enhancing performance.

Injury Prevention Effectiveness

Whether preventive exercises or static stretching included in warm-up protocols can acutely reduce injury risk remains inconclusive.[61,70,80] In particular, the acute protective effects of a single warm-up session are conflicting and deserve further study.

Practical Application

This Delphi consensus on warm-up strategies provides a foundation for terminology, structure, component selection, and sport-specific applications, including PAPE and readiness monitoring. This practical framework serves to better inform research design and more effective evidence-informed warm-up strategies across sports disciplines. However, practical optimization of warm-up strategies will require further evidence on refinement and customization for different sports and athletes.

Conclusion

In this consensus, agreement among international experts confirms that warm-ups are structured, multifactorial interventions integrating active and passive components to enhance readiness for both training and competition. An athlete's readiness can also be monitored with different tools. The consensus emphasizes that conditioning activities and PAPE are essential yet context-dependent components, requiring individualized load management to maximize performance enhancement while minimizing fatigue. The inclusion of preventive exercises in the warm-up can chronically reduce injury risk, as in other parts of the training session, but their acute effect(s) is not supported.

Warm-up protocols remain underpinned by heterogeneous evidence, which should be refined in further studies exploring the interactions between warm-up components to optimize their timing and sequencing. Sport-specific models need to be developed and individualized, considering several intrinsic and extrinsic factors related to the athletes.

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