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Consensus

Practical recommendations on stretching exercise: A Delphi consensus statement of international research experts

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Abstract

Background: Stretching has wide appeal, but there seems to exist some mismatch between its purported applications and what the evidence shows. There is compelling evidence for some stretching applications, but for others, the evidence seems heterogeneous or unsupportive. The discrepancies even affect some systematic reviews, possibly due to heterogeneous eligibility criteria and search strategies. This consensus paper seeks to unify the divergent findings on stretching and its implications for both athletic performance and clinical practices by delivering evidence-based recommendations.
Methods: A panel of 20 experts with a blend of practical experience and scholarly knowledge was assembled. The panel meticulously reviewed existing systematic reviews, defined key terminologies (e.g., consensus definitions for different stretching modes), and crafted guidelines using a Delphi consensus approach (minimum required agreement: 80%). The analysis focused on 8 topics, including stretching's acute and chronic (long-term) effects on range of motion, strength performance, muscle hypertrophy, stiffness, injury prevention, muscle recovery, posture correction, and cardiovascular health.

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Results: There was consensus that chronic and acute stretching (a) improves range of motion (although alternatives exist) and (b) reduces muscle stiffness (which may not always be desirable); the panel also agreed that chronic stretching (c) may promote vascular health, but more research is warranted. In contrast, consensus was found that stretch training does not (a) contribute substantively to muscle growth, (b) serve as an all-encompassing injury prevention strategy, (c) improve posture, or (d) acutely enhance post-exercise recovery.
Conclusion: These recommendations provide guidance for athletes and practitioners, highlighting research gaps that should be addressed to more comprehensively understand the full scope of stretching effects.

Keywords: Range of motion; Strength; Movement preparation; Recovery; Evidence-based practice; Stretch

1. Introduction

Flexibility is recognized as 1 of 5 key physical fitness components directly impacting health,[1,2] with stretching being the most researched, applied, and debated method for its improvement.[2–4] Traditionally, stretching has been an integral component of physical training, warm-up, and cool-down routines seeking to improve flexibility,[4–7] prevent injury,[5,8–11] and accelerate recovery.[12,13] In rehabilitation, it has frequently been used with the objective of restoring muscle extensibility and range of motion (ROM) or improving posture.[14–17] Recent studies applied stretching to increase strength and/or muscle mass[18–22] and enhance cardiovascular health.[23,24] However, stretching does not always achieve the assumed effects, and there are discrepancies and a lack of consensus in the use of terms and definitions. As an example, Medeiros and Lima[25] were not able to perform a meta-analysis of stretching effects on muscular performance due to excessive between-study methodological heterogeneity. This problem may be attributed at least in part to a lack of standardized definitions of stretching and its different modes. For instance, Behm[26] described dynamic stretching as movement performed over the full ROM of a joint, which would also include resistance training (RT) at long muscle lengths.[27] In contrast, Warneke and Lohmann[28] defined dynamic stretching as any intervention including controlled back and forth movements in the end-ROM, explicitly distinguishing it from full-ROM RT. Differential and often incoherent definitions of stretching—sometimes even within the same research article—have been highlighted by a recent scoping review.[29] This lack of clarity or consistency may influence existing guidelines on stretching applications.

The literature also presents inconsistent accounts regarding the effectiveness of stretching interventions. An example is how pre-exercise stretching affects performance, with studies reporting both positive and negative effects.[5,28,30,31] These effects may be moderated by a plethora of factors, such as the stretching typology (e.g., static *vs.* dynamic), volume (e.g., duration), intensity (e.g., stretch sensation *vs.* discomfort or pain), or timing (e.g., before *vs.* after training or competition). In addition, a time lag exists between the generation of scientific evidence and its adoption into exercise guidelines. For example, the evidence failed to support the effectiveness of post-exercise stretching to improve recovery,[13] but the American Heart Association still promotes it as a suitable recovery method.[32]

Exercise science aims to guide practitioners and clinicians toward best practice models through the provision of evidence-based recommendations.[33] In view of the large amount of topical literature published at a high frequency, the heterogeneity of methods, and the lack of clear consensus and communication among researchers, practitioners face serious challenges in identifying fields of application and selecting appropriate training practices. A recent survey revealed that health and sports experts were unaware of the published evidence available about muscle stretching, missing clear guidance in fields of application.[34] Against this background, this consensus aimed to provide evidence-based practical recommendations for healthy populations from active researchers in the field of stretching, geared for communication to both practitioners as well as health and exercise professionals and researchers.

2. Methods

A panel of experts actively engaged in stretching research, many with substantial experience in sports practice and research (Table 1), was formed to develop clinical recommendations using a structured consensus process.

All procedures adhered to current guidelines for consensus statements and were aligned with similar previous initiatives.[35–37] The process comprised 3 steps. First, the relevant literature (systematic reviews) on stretching-related topics was identified to provide panel members with current syntheses of the available evidence. Second, definitions of stretching were generated by consensus. The third and main task of the panel was the development of recommendations on practical stretching applications in health- and sport-related practice. Steps 2 and 3 were both performed using a Delphi consensus process following relevant guidelines (Fig. 1).

2.1. Panel selection

To recruit panel members, the most active researchers in the field of muscle stretching were identified by means of searches in Web of Science and databases such as Expertscape.com. The criterion to qualify as an expert was a minimum of 5 peer-reviewed articles on the practical application of stretching. If several authors from the same research group fulfilled the requirement, either the group leader or the researcher with the highest number of topical research articles was contacted to prevent imbalances on the panel.

Of the 23 invited individuals, a total of 20 experts agreed to contribute (Table 1). The panel consisted of researchers from 12 countries (Australia, Austria, Canada, Greece, Germany, USA, UK, Japan, Italy, France, Portugal, and Spain) and 4 continents. Two of the authors (AZ and OD) were women.

Table 1
Expertise information of the panel, considering practical background as well as research output in the area of stretching.

Author	Background from practice	Research expertise
José Afonso	20 years as a volleyball coach, including head coach of National Teams, and multiple times national champion; currently, federated Brazilian Jiu-Jitsu athlete and Muay Thai practitioner.	5 articles in the field of stretching, including the largest scoping review to date concerning the applications of stretching in competitive athletes.
Francisco Ayala	Strength and conditioning practitioner for over 15 years and external consultant of professional sport organizations (including football and basketball clubs) on injury prevention and rehabilitation.	Main topics: More than 15 articles in the field of stretching (acute and chronic effects on range of motion and neuromuscular performance), together with an international doctoral thesis on the topic.
Nicolas Babault	Strength and conditioning coach for youth and adults, including elite athletes (mostly track and field athletes).	>15 articles in the field of stretching, including acute studies, survey, intervention research, and reviews.
David G. Behm	Strength and conditioning coach for Canadian Olympic curling gold medalists as well as for university football, and provincial tennis and squash teams.	>80 stretching-related articles, including cross-sectional, longitudinal training, and acute studies, and systematic reviews with meta-analysis as well as association position stands.
Anthony J. Blazevich	Strength and conditioning practitioner with 30 years of experience with athletes from youth to Olympic and international sports (team) levels; consultant to institutes/academies of sport internationally.	>40 articles in the field of stretching, including cross-sectional studies, acute studies, intervention research, and systematic reviews with meta-analysis.
Pablo Costa	Researcher with nearly 20 years of experience in many areas, including stretching, flexibility, injury risk, resistance training, balance, hypertension, hypotension, type 1 and 2 diabetes, and cardiovascular disease.	Over 120 research publications investigating the physiological effects of exercise on performance, health, and fitness.
Olyvia Donti	Artistic gymnastics coach with 25 years of experience with female gymnasts from youth to Olympic and international level; International Gymnastics Federation (Olympic Games, World Championships, *etc*.); former national level gymnast.	>15 articles in the field of stretching, including cross-sectional studies, acute studies, intervention research, and systematic reviews with meta-analysis.
Sandro R. Freitas	Strength and conditioning practitioner and exercise physiologist for over 20 years, and Capoeira teacher with more than 25 years of practice.	>25 articles and a handbook in the field of stretching, together with a doctoral thesis on the topic.
Anthony D. Kay	Strength and conditioning coach and practitioner for over 30 years; karate practitioner and instructor ranging from youth to national levels.	Main topics: Stretch-induced acute and chronic changes in joint range of motion, stretch tolerance, and tissue stiffness; >25 articles in the field of stretching, including acute and chronic studies, and systematic reviews with meta-analysis.
Andreas Konrad	Strength and conditioning coach for youth soccer players.	>50 articles in the field of stretching, including acute studies, intervention research, and systematic reviews with meta-analysis.
Stefano Longo	Former karate athlete at the national level for >10 years; karate coach for >20 years; teacher at the School for Circus Arts for 10 years.	>10 articles in the field of stretching, including acute and long-term studies focusing on the physiological mechanisms behind stretch-induced adaptations.
Paulo H. Marchetti	Strength and conditioning coach, Certified Strength and Conditioning Specialist (NSCA/USA), Certified Bodybuilding Coach (ASFA/USA), Specialist in Exercise Physiology (UNIFESP/Brazil), and Specialist in Sports Training Methodology (UNIFESP/Brazil); Brazilian Taekwondo athlete.	Published over 150 peer-reviewed articles, 11 books, and 16 book chapters on biomechanics and resistance training.
Masatoshi Nakamura	A physical therapist with over 15 years of experience, working in rehabilitation, focusing on orthopaedic disorders and sports injuries.	Main topics: Stretching-induced flexibility changes (range of motion and passive stiffness); >50 articles in the field of stretching, including acute and chronic studies, and systematic reviews with meta-analysis.
Arnold Nelson	Emeritus Kinesiology professor and researcher on the influences of stretching upon athletic performance.	Co-author of ∼20 peer-reviewed published articles on stretching and performance. Co-author of the book *Stretching Anatomy*.
Antoine Nordez	None.	>35 articles (chronic training, acute effects, cross-sectional, and systematic reviews) and a doctoral thesis on the topic.
Ewan Thomas	Strength and conditioning coach and calisthenics athlete at the national level for over 10 years; osteopathic manual therapist.	Author of 15 articles in the field of stretching, primarily focusing on the effects of stretching other than flexibility, including acute and chronic studies, and systematic reviews with meta-analysis.
Gabriel S. Trajano	Exercise physiologist and strength and conditioning practitioner with over 20 years of experience.	>15 journal articles in the field of stretching.
Konstantin Warneke	Strength and conditioning coach for elite athletes (basketball, volleyball, soccer), youth to adults at the national level; sports therapist (orthopedic and neurological diseases).	Main topics: Movement preparation, stretch-mediated hypertrophy and strength increases, dose-response relationships; >25 articles in the field of stretching, including cross-sectional studies, online surveys, acute studies, intervention research, and systematic reviews with meta-analysis.
Jan Wilke	Sports therapist in elite football players; strength and conditioning coach of former tennis world No. 1, Angelique Kerber;	Author of 15 articles in the field of stretching, primarily focusing on the effects of stretching other than flexibility, as well as the impact of exercise on injury prevention and in pathological cohorts.

(*continued on next page*)

Table 1 (Continued)

Author	Background from practice	Research expertise
	consultant for professional organizations in the USA (e.g., MLB).	
Astrid Zech	Degrees in physical therapy, sports science, and psychology. Experience as physical therapist in clinical settings and elite sports (swimming, athletics, handball, canoeing).	>100 articles in sports science, rehabilitation, and biomechanics.

Abbreviations: ASFA = American Sport and Fitness Association; MLB = Major League Baseball; NSCA = National Strength and Conditioning Association; UNIFESP = Universidade Federal de São Paulo.

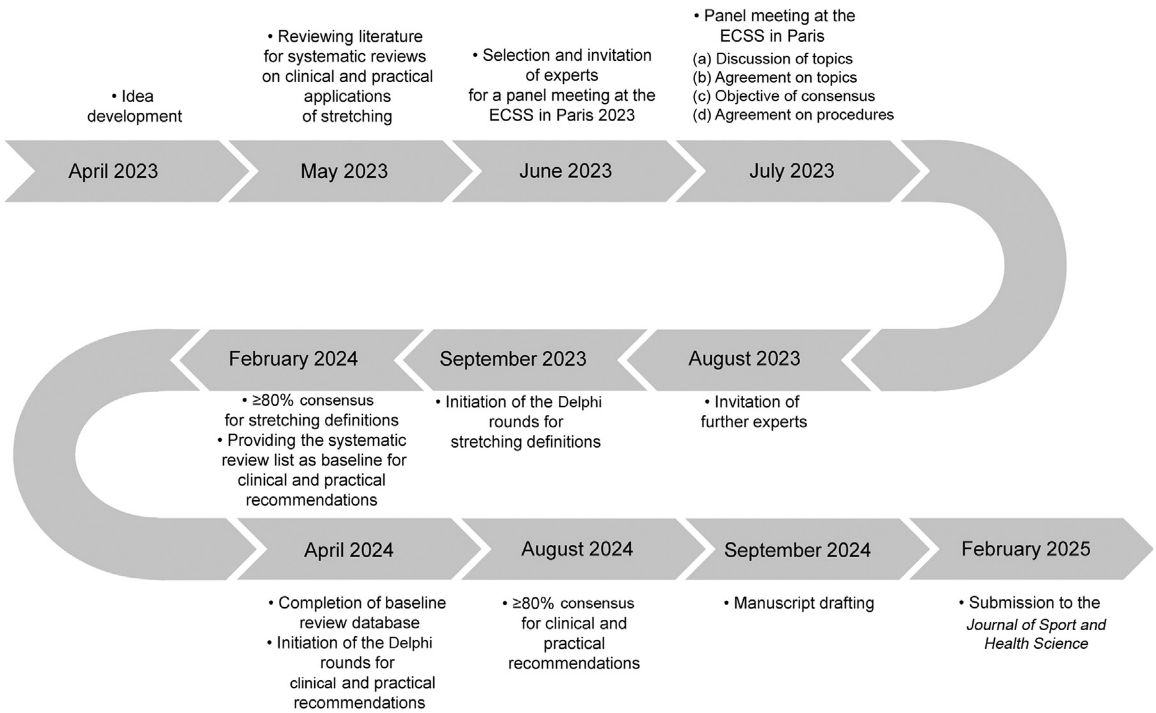

Fig. 1. Timeline illustrating the consensus process starting in April 2023, with February 2025 as the date of submission. ECSS = European College of Sport Science.

The panelists had various educational backgrounds, including physiotherapy, sports medicine, sports science, kinesiology, athletic training, exercise physiology, osteopathy.

Following invitations in April and May of 2023, the inaugural panel meeting was held at the European College of Sport Science Congress in Paris (July 2023). At this meeting, authors were first informed about the process and procedures and, subsequently, potential topics were discussed. Ten panel members attended the meeting physically, while digital participation was offered to the remaining experts.

2.2. *Evidence review*

During the initial meeting, the panelists agreed to include topics for which at least 1 systematic review was available. All authors provided relevant papers, and additional systematic searches using Web of Science, PubMed, and Scopus were performed to create a database of evidence-based background information. As a result of this search, the identified topics comprised acute and chronic stretching effects on: (a) ROM, (b) strength, (c) hypertrophy, (d) stiffness, (e) injury risk, (f) post-exercise recovery, (g) muscular imbalance and posture, and (h) the cardiovascular system. For each topic, it was decided to dissociate acute (immediate) and chronic (after intervention periods of at least 2 weeks) effects. Whereas there is research regarding the effects of stretching on post-exercise recovery, there were no systematic reviews found on the role of stretching for recovery from injury or re-injury.

2.3. *Consensus process*

2.3.1. *Step 1: Stretching definitions*

A Delphi process was used to find panel consensus on definitions of stretching and related sub-typologies. Briefly, the Delphi method is a multi-stage procedure that attempts to achieve agreement between multiple persons who all receive and then judge topical statements.[38–40] The panelists review and submit their input in a blinded manner to guarantee unbiased discussion. Several rounds are performed until a pre-specified consensus threshold has been reached.

In each of the 4 Delphi rounds of this study, the input (including revisions to the original statements and arguments for or against revisions) received from the panelists was grouped, synthesized, and sent back to the authors. The consensus process continued until at least an 80% agreement was achieved for each statement.[38,41,42] Blinding was ensured by sending statements exclusively to the first author (KW) who anonymized the responses before forwarding them to the panel. To start the process, KW suggested initial definitions based on a literature search. Definitions were created for the most common stretching typologies[29]: static, dynamic, and proprioceptive neuromuscular facilitation (PNF) stretching.

2.3.2. Step 2: Stretching recommendations

The final and main step included the development of clinical guidelines for stretching. As in Step 1, the Delphi method was applied, and the first author (KW) suggested initial recommendations based on the available evidence (findings from the literature search conducted in Step 1). Again, a minimum agreement of 80% was defined as consensus. Besides the final recommendations provided per topic, a comment ("additional remarks") was prepared for each statement to document discrepant opinions and further information to contextualize the achieved consent in light of issues and arguments provided by authors not or not totally agreeing with the group consensus.[43,44]

3. Results

3.1. Stretching definitions

Three rounds were needed to find consensus on stretching definitions. Agreements were 90% for static, 80% for dynamic, and 85% for PNF stretching (Fig. 2). When used, the term "soft tissue" does not refer to bony structures, but namely muscles, tendons, aponeuroses, fasciae, ligaments, nerves, and vascular bundles. The final definitions are:

Static stretching elongates soft tissue beyond slack length by holding a joint position where passive resistance, stretch sensation, or discomfort are experienced. It can be performed assisted, if the muscle is lengthened by an external force without voluntary muscle activation (e.g., stretch band or a partner), or unassisted (self-stretching).

Dynamic stretching is the cyclic application of unloaded motion elongating the soft tissue (no external resistance). Stretch sensation or tissue resistance are reached without a static phase. As a variation, ballistic stretching differs from other dynamic by using faster, less controlled bounce-like actions performed to or near end range of motion.

PNF stretching combines static stretching and submaximal-to-maximal muscle contractions. In contract-relax (CR) stretching, the target muscle is contracted isometrically and subsequently stretched in a relaxed non-contracted state. In antagonist-contract (AC) stretching, the target muscle is stretched with simultaneous antagonist contraction. In contract-relax-antagonist-contract (CRAC) stretching, the target muscle is contracted and then stretched uncontracted with simultaneous antagonist contraction.

3.2. Clinical recommendations

3.2.1. ROM (acute)

For decades, increasing ROM acutely has been an important part of warm-up routines.[9,11] Topical systematic reviews with meta-analysis clearly demonstrate its effectiveness in enhancing ROM in the short-term.[2,5,7] The following recommendation reached an agreement of 95% after 3 Delphi rounds (Fig. 2):

If stretching is used to improve ROM acutely, the panel recommends a minimum of 2 bouts of 5 s to 30 s of soft tissue stretching. The panel does not recommend any specific technique in particular, since all show similar effects.

Additional remarks: Recent literature demonstrated no differences between stretching and other methods, such as foam rolling,[45,46] cycling, jogging, eccentric resistance training, heat application, or vibration.[47] It can be therefore concluded that the inclusion of stretching into warm-up routines is not essential, but it is a viable option to acutely increase ROM in healthy populations. Additionally, the meta-analysis published by Behm et al.[7] found no statistically significant difference between low- and high-intensity stretches. Not all joints or muscles respond similarly to stretching. For example, the Konrad et al.[4] meta-analysis on chronic stretching effects reported a lack of significant ROM improvements with the quadriceps (based on only 3 measures), while the Behm et al.[7] meta-analysis of acute stretching effects on ROM highlighted non-significant improvements with the hip adductors (based on 4 studies). A number of studies have demonstrated that ankle dorsiflexion ROM is limited compared to many other joint excursions due to the bone configuration.[48] Thus, while ROM increases have been reported with as little as 5 s of stretching, typically 30−60 s per muscle are recommended.[48] Some muscles, due to their volume, architecture, or resting tensions, may need longer durations than others to achieve appreciable ROM improvements.

3.2.2. ROM (chronic)

Enhanced flexibility in the long-term is sought after by athletes and practitioners, and it is associated with improvements in the mortality and morbidity of middle-aged men and women.[49] Available systematic literature reviews with and without meta-analysis corroborate the beneficial effects of long-term stretching on ROM.[2,4,20,50] A meta-analysis by Konrad et al.[4] showed significant ROM increases for all stretching typologies (static, dynamic, and PNF), but with large magnitude effect sizes for static and PNF stretching; dynamic stretches showed moderate magnitude improvements.[2] The panel reached 95% consensus in the third round for the following recommendation (Fig. 2):

If stretching is used to enhance flexibility chronically, the panel advises to use static or PNF over dynamic stretching.

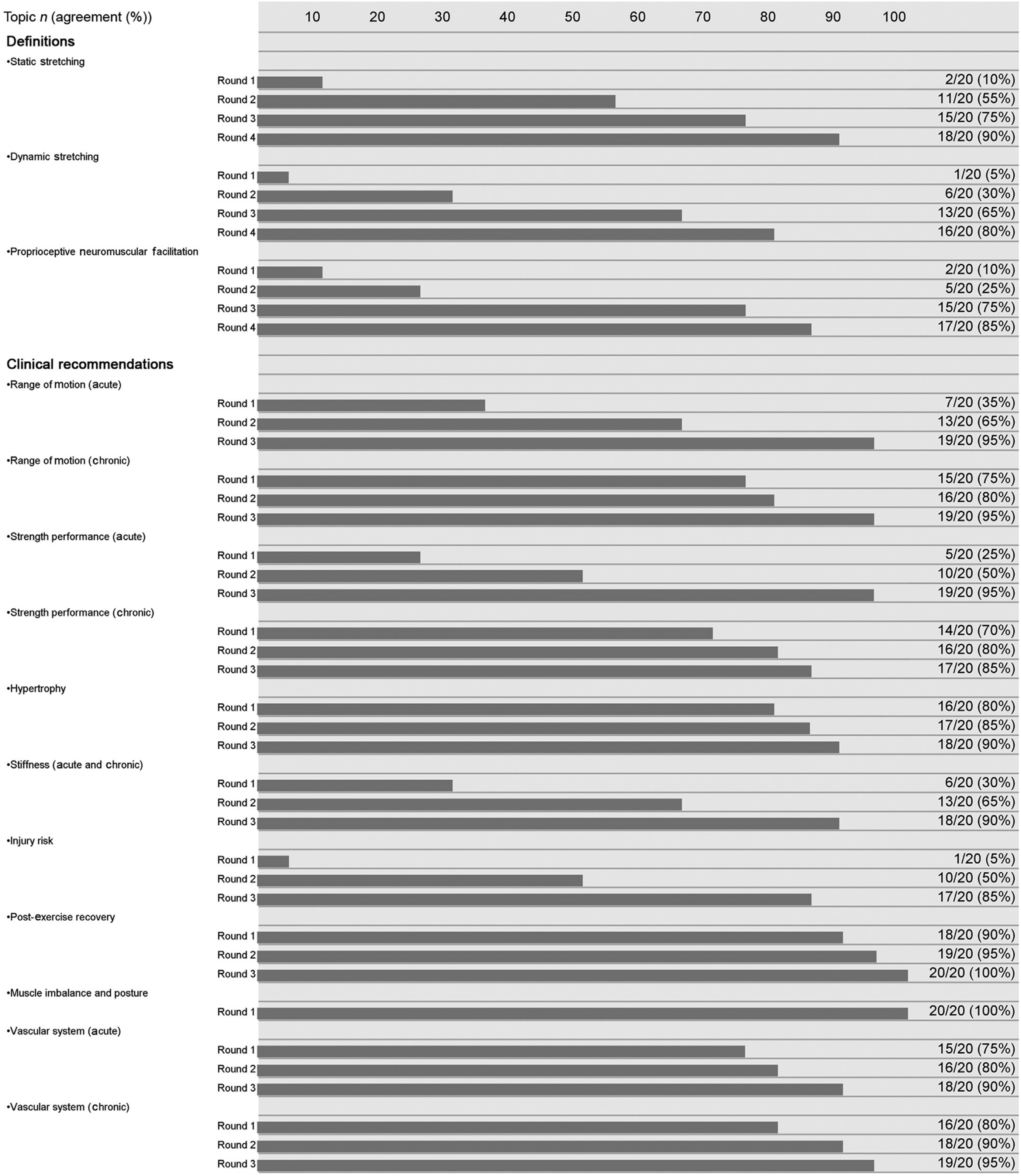

Fig. 2. Agreement within the panel for each Delphi round until reaching ≥80% consensus.

It is recommended to perform 2−3 sets daily, each held for 30−120 s per muscle/soft tissue, to reach the highest possible weekly volume.

Additional remark: As outlined for acute effects, alternatives can be used to achieve chronic ROM increases. Alizadeh et al.[27] and Afonso et al.[51] reported full-ROM RT to enhance

ROM to at least a similar degree, especially if a focus is given to the eccentric phase.[52–54] Additionally, foam rolling has been shown to induce comparably large ROM increases,[55,56] while other interventions such as eccentric resistance training are also possible.[54,57] Additionally, Konrad et al.[4] and Ingram et al.[2] found no significant difference between high- and low-intensity stretches in the most recent meta-analysis. At this point, no clear recommendation can be provided. For healthy, young adults, the choice of methods for chronically improving ROM can be left to individual preference.

3.2.3. Strength performance (acute)

A growing number of studies and reviews noted an acute decrease in force production when prolonged static stretching was applied *prior to* the strength or performance assessments.[5,48,58–62] The available evidence was summarized in 2 systematic reviews performed in 2012 and 2013,[60,61] suggesting avoidance of longer-duration (>60 s) static stretching per muscle group *prior to* athletic performance. More recent evidence reported by Warneke and Lohmann[28] confirms the stretch-induced force deficits induced by prolonged static stretching with a proposed threshold of approximately 60 s duration per muscle.[5,11,28,58,60] However, the authors demonstrated no such effect for shorter durations. The panel found agreement with 95% after 3 rounds for the following recommendation (Fig. 2):

The panel does not recommend prolonged (>60 s per muscle) static stretching prior to maximal or explosive contractions in isolated muscle groups (meaning static calf stretching should be avoided prior to maximal strength efforts). However, short-duration static stretching incorporated into a dynamic warm-up and dynamic stretching do not cause such impairments. The panel recommends these alternatives if stretching is used during warm-up for strength/speed/explosiveness.

Additional remark: It should be noted that performance has many more facets than enhanced ROM, strength, quickness, and power. The evidence clearly demonstrates that incorporating short durations of static and dynamic stretching within a warm-up can increase ROM and are very unlikely to cause adverse effects (on average). Yet, practitioners may consider some of the alternatives used instead of prolonged static stretching (e.g., short duration static stretching, dynamic stretching, foam rolling, or jogging), which do not lead to an immediate force deficit.[63] Stretching *prior to* strength/explosiveness activities, therefore, always requires careful planning and communication with the exercising individual.

3.2.4. Strength performance (chronic)

Recent evidence suggests stretching interventions can increase force production capacity and strength under specific circumstances.[25,64,65] Although stretching durations commonly associated with ROM increases appear insufficient for this purpose, applying higher volumes through increased stretching durations and frequency per week[18,20,22] may increase maximal strength, albeit with a small magnitude. The panel reached 85% consensus for the following statement (Fig. 2):

The panel does not recommend stretching as a primary strategy to enhance strength. Yet, the panel agrees that small increases achieved by chronic static stretching may be of value for some individuals unable or unwilling to perform dynamic progressive overload resistance exercise. In this case, high-dosage static stretching (at least 15 min per session per muscle for at least 5 × per week) over a period of at least 6 weeks is recommended.

Additional remark: As indicated in the recommendation, RT and related methods represent the primary strategies to enhance strength in the long-term, presenting much higher efficiency (less time is necessary to reach comparable effects). The small beneficial effects of stretching may still be of value for some, for example, during the rehabilitation process or in elderly individuals, if RT or other methods are contraindicated. Furthermore, enhanced strength would improve compensatory responses to movement perturbations and thus contribute to balance improvements in the elderly.[66] However, before recommending stretching as a potential alternative to more active routines, research must address the role of stretching intensity when seeking to improve strength.

3.2.5. Hypertrophy

Similar to strength training, while a single bout of resistance (or stretch) training will not increase muscle hypertrophy, recent evidence demonstrates a beneficial, small-magnitude impact of chronic static stretching of long durations and high volumes on muscle hypertrophy.[18,20] The panel agreed with 90% consensus to the following recommendation after the third Delphi round (Fig. 2):

The panel does not recommend stretching as a primary strategy to enhance muscle mass. In some cases (e.g., if resistance exercise is not feasible or undesired), the panel agrees it may be of relevance. In this case, the panel recommends daily static stretching for >15 min per day per muscle over a period of at least 6 weeks. Yet, the relationship between attained effects, which are small, and invested time requires careful consideration.

Additional remark: Although stretch-mediated hypertrophy requires relatively high volumes, effects can still have practical relevance. Behm et al.[67] suggested to include this training alternative into the daily life of sedentary populations (e.g., during office work, watching TV, *etc.*), which may be difficult for active RT interventions. Since greater muscle mass permits higher uptake of blood glucose, another potential area of application includes its use in exercise programs for obese type 2 diabetes patients aiming to improve blood glucose levels.[24] Nevertheless, limited research addressing stretching intensity as a potential moderator for structural effects[19,68] prevents final conclusions.

3.2.6. Stiffness (acute)

Muscle, tendon, or musculotendinous stiffness decreases have been associated with ROM increases.[69,70] Conversely, an increase in stiffness may be related to impaired ROM and pain.[71] Recent literature[72] has shown that, under specific exercise conditions (i.e., stretches of long duration, supervised, and of high intensity), stretching can be a sufficient stimulus to modulate passive properties such as muscle stiffness. The panel reached the following recommendation with 90% agreement after the third round (Fig. 2):

If the goal is to acutely reduce passive muscle-tendon stiffness, the panel recommends static stretching for more than 4 min per muscle. As shorter durations and other stretching techniques have not consistently produced stiffness reductions, they cannot be recommended for this purpose at this time.

Additional remark: Although a decrease in stiffness is commonly interpreted as positive, it must be noted that it is not always beneficial. Energy storage and release in tendons could be negatively affected by stretch-induced stiffness reductions, thus hampering stretch-shortening cycle performance.[73–75] Applicants are directed to consider stretch-induced advantages (increased ROM) against potential disadvantages (possible negative effects on performance). Another issue is that most available studies exclusively focused on stretch adaptations in the skeletal muscle, tendon, and muscle-tendon unit (MTU). Although the deep fascia and parallel elastic component acutely adapt to mechanical stimuli,[76] evidence on its involvement in stretching effects is scarce, with the exception of a single randomized controlled trial addressing this topic.[77]

3.2.7. Stiffness (chronic)

Past research has discussed, with controversy, changes in passive properties induced by stretching, with flexibility adaptations primarily being attributed to increases in passive peak torque (higher stretch tolerance or discomfort threshold).[78] In contrast, the latest reviews demonstrate stretching interventions sufficiently moderate stiffness chronically.[72,79] After 3 rounds, there was 90% consensus on the following recommendation (Fig. 2):

The panel recommends supervised and intensive static stretching of at least 4 min per muscle, 5 days per week, for at least 3 weeks when aiming to decrease muscle stiffness chronically.

Additional remark: As for acute stiffness, applicants need to consider that chronic stiffness reductions may be both beneficial and detrimental. In addition, analogous to the acute effects, there is controversy regarding the adaptation of the involved tissues. Presently, passive stiffness reductions in response to stretching are accompanied by changes in muscle stiffness.[72,79] Tendon stiffness remained unaffected by stretching, while MTU stiffness was exclusively moderated acutely, not chronically.[69] However, no evidence is available on deep fascia adaptations to chronic stretching, and further research in this area is needed.

3.2.8. Injury risk

While there is no evidence that a single bout of stretching (acute) can reduce injury risk or incidence, chronic stretch training is one of the most often cited methods for injury prevention. The scientific evidence does not provide clear support for its application, and most previous systematic reviews do not demonstrate a general (all-cause injury) preventive effect of stretching.[80–82] Takeuchi et al.[83] provided the most recent systematic review article, which reported that static stretching decreases muscle but not tendon injury risk. Yet, in the studies included in this review, such decreases in muscle injury risk were accompanied by increased bone and joint injury risk.[84] After 3 Delphi rounds, the panel reached 85% agreement for the following recommendation (Fig. 2):

The panel does not recommend stretching for injury prevention in general. The panel acknowledges that initial evidence suggests static stretching may reduce the incidence of muscle injuries. Notwithstanding, athletes and coaches thus need to carefully consider benefits (small effect) and invested time.

Additional remark: As for some of the other outcomes, the panel underlines that a variety of methods are effective for preventing injury. For instance, Lauersen et al.[85] reviewed the available scientific literature on common exercise routines to moderate injury risk and found strength, stability, and postural control interventions to be beneficial. Practitioners should also be aware that the number of studies on the association between stretching and injury risk is still small and suggests trade-offs (e.g., fewer muscle injuries may be compensated for with more bone and joint injuries). The acute effects are not clearly investigated: studies assessing the effects of pre-training stretching on injury risk are only assessing chronic effects. Practitioners should consider this when including stretching with the aim to reduce injuries.

3.2.9. Post-exercise recovery

Stretching is frequently applied during post-exercise cool-down routines (e.g., when seeking to reduce delayed onset muscle soreness (DOMS) or improve general post-workout recovery),[12,13] although it has lost favour in more recent exercise guidelines.[86] Most research on post-exercise stretching used static stretching or PNF, so it is unclear whether dynamic stretching can play a role.[13] Based on the available systematic reviews not demonstrating beneficial effects on DOMS, recovery of ROM, or strength levels either immediately after exercising or up to several days later in comparison to passive recovery (i.e., rest),[13,80,87] the panel recommendation reached 100% agreement after 3 rounds (Fig. 2):

Based on the current evidence, the panel does not recommend stretching as a post-exercise recovery routine although overall confidence in the available evidence is low.

Additional remark: While stretching may be of psychological value for some individuals, its application for alleviation of DOMS not only lacks evidence but also theoretical foundation. Recent evidence has demonstrated the often-assumed muscular processes such as z-line streaming, inflammation, or accumulation of lactate and free radicals are not related to DOMS symptoms. Instead, DOMS seems to originate from the deep fascia.[88] It is a marker of unaccustomed training. As such, it is more likely to occur with less highly trained individuals (i.e., general population of sedentary or recreationally active individuals). On a surface level, DOMS seems more consistent with unusual exercise in terms of mode and/or dose, and so DOMS should not be a common phenomenon after regular training sessions. However, most studies assessing the effectiveness of post-exercise stretching on recovery do, in fact, adopt exercise protocols that are purposefully conducive of DOMS, and therefore more research is required under more "ecological" conditions.[13] In sum, as existing reviews do not show a detrimental effect of post-exercise stretching on recovery, its use may be left to individual preference.[13,80,87]

3.2.10. Muscle imbalance and posture

In physical therapy, a well-known approach[89] is to stretch the ventral muscles (e.g., hip flexors, pectoralis muscles) and to strengthen the dorsal muscles (gluteal muscles, trapezius) with the aim of improving spinal alignment postural issues. A systematic review by González-Gálvez et al.[90] provided evidence for the efficacy of the combined approach (strengthening and stretching). However, Withers et al.[91] found only 1 stretching study as a stand-alone intervention to counteract the upper crossed syndrome (shortened pectoralis). The latest evidence update was provided in 2024 by Warneke et al.[92] The review included a total of 23 studies and confirmed effects of isolated strengthening, while isolated stretching was found to be ineffective. This led to the following panel recommendation after 1 round with 100% agreement (Fig. 2):

Based on the current evidence, the panel does not recommend stretching to promote postural changes.

Additional remark: While strengthening weak muscles seems advisable to change posture, it will be of interest to examine whether stretching with higher volumes and intensities than those typically used is effective.[18,19]

3.2.11. Vascular system (acute)

While increasing muscle length during stretching, elements within the muscle (e.g., blood vessels) undergo similar strain.[93] The latest systematic review with meta-analysis[23] assessed acute and chronic effects on blood pressure, heart rate and heart rate variability, arterial stiffness, and endothelial function, reporting positive effects. The panel recommendation reached 90% agreement after 3 rounds (Fig. 2).

If stretching is used to achieve acute beneficial effects on the circulatory system as an additional strategy supplementing others (e.g., pharmaceuticals), this panel recommends 1 bout of at least 7 min of static stretching per muscle.

Additional remark: Using stretching as treatment or prevention for conditions affecting the vascular system is of interest to practitioners and therapists. Yet, the number of studies is still small, and other treatments such as foam rolling or low-to-moderate intensity RT seem to provide similar benefits.[94−96] Additionally, underlying mechanisms are not clear, calling for further investigations into whether the stretch-induced strain or other factors, such as impacted sympathetic-parasympathetic balance, explained the effects.[97] In addition, most trials included healthy or young individuals. Consequently, the recommendation should be taken with some caution.

3.2.12. Vascular system (chronic)

Similar to the acute effects, the available evidence for long-term application is scarce but points to a beneficial impact on the vascular system.[23,98] The panel recommendations reached 95% agreement after 3 rounds (Fig. 2):

If stretching is performed to reduce arterial stiffness, increase heart rate variability, and improve endothelial function, the panel recommends 15 min of static stretching per muscle, performed 5 days per week for at least 4 weeks. The panel agrees static stretching could be an alternative for those unable to engage in active (therapeutical) exercise.

Additional remark: The recommendation needs to be interpreted with some caution. The improvement of the cardiovascular parameters observed within the included studies does not appear uniform across interventions. The effects of stretching on arterial stiffness are large when stiffness is measured throughout the body (including limbs and thorax), while they are moderate when measured only in the thorax. This suggests vascular improvements are specific to the areas subjected to the mechanical stretch.[99] The range of proposed effects (e.g., on pulse wave velocity) are as large as for resistance training[100] and endurance training.[101,102] In summary, our recommendation cannot be interpreted as a clinical indication in cases of arterial stiffening or endothelial and autonomic disfunction, and it does not substitute for medical advice. Moreover, the term "therapeutic", as used in the recommendation, means the panel is more clearly recommending this application for clinical populations who may not be able to engage in other, perhaps more active, exercise forms.

3.3. Summary of panel recommendations

The process with round-to-round percentage agreement can be reviewed in Fig. 2. The recommendations resulting from the extensive debate are graphically illustrated in Fig. 3 to provide a summary illustration.

4. Discussion

This consensus paper combined practical expertise and scientific evidence to provide guidance in the design of

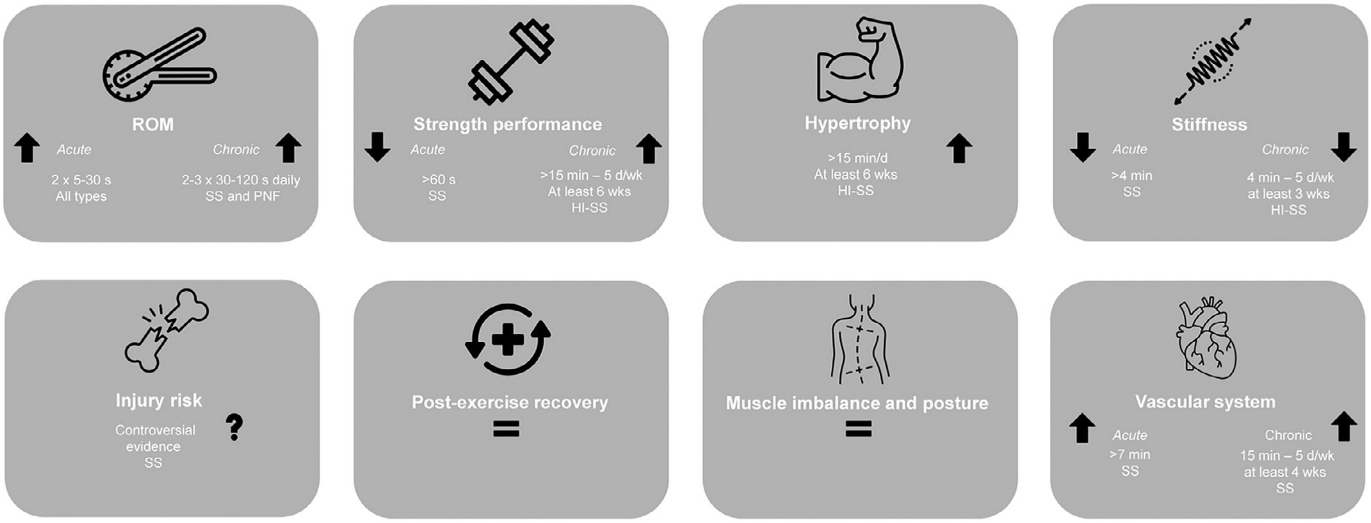

Fig. 3. Graphical summary of the final panel recommendations in the 8 topics. ↑ indicates stretching promotes measures; ↓indicates stretching declines measures; = means no effect; ? means that no clear evidence exist, * means whether a decrease in stiffness can be considered an improvement depends on the context and specific goals. d/wk = days/week; HI = high intensity; PNF = proprioceptive neuromuscular facilitation; SS = static stretching.

stretching interventions. It is challenging for coaches, therapists, athletes, and practitioners to find unequivocal information on stretching effects and applications, and knowledge of the scientific evidence related to stretching is poor.[34] We also suggest uniform definitions for the most popular typologies (static, dynamic, and PNF stretching), thereby responding to the requests of several review articles to produce homogeneous and comparable stretching protocols.[25,28]

Our Delphi study gathered experts and working groups from different fields of stretching in order to present balanced views on the topic. Against this background, it is noteworthy that consensus was found for each of the discussed statements (Fig. 2). The generated definitions and recommendations represent a significant achievement helping to (a) communicate scientific knowledge to practitioners and clinicians who are willing to include stretching in their exercise, training, or treatment routines, and (b) improve comparability of future research in further fields while clarifying misconceptions that stem from beliefs devoid of substantial evidence.

4.1. The stretching debate

Although stretching improves ROM, strength/muscle size, and cardiovascular health, this does not automatically make stretching an optimal stand-alone exercise option. As shown in this consensus statement, stretching affects multiple aspects of health, well-being, and physical performance, and extends well beyond joint flexibility or ROM. Stretching can also be performed by those who are unable to engage in more demanding types of exercise, such as RT or endurance training. Stretching has good feasibility and can be applied at any time, with no costs or complex infrastructural requirements (the exception being PNF, which often requires a partner or machine and is technically more challenging). Stretching may constitute a good solution to mitigate the effects of a sedentary lifestyle.

Depending on the goal, stretching may not be the only solution available, or the most effective one. For example, while alternative routines were effective in increasing ROM acutely (e.g., eccentric RT, foam rolling,[45] other dynamic activities), there is no consistent evidence demonstrating the superior effects of stretching to alternative routines for acute ROM gains.[47] In addition, while some strategies such as RT have beneficial effects on injury prevention, evidence is inconclusive for stretching. Likewise, RT can induce postural changes, while stretching seems largely ineffective in this regard. In summary, practitioners and exercising individuals need to carefully consider the benefits and invested time, as well as personal preferences.

4.2. The dissemination problem

We identified a variety of caveats and perspectives for future research. The practical significance of recommendations such as those presented here is mainly determined by the degree of implementation and awareness in the target population. Previous studies have shown that only 2%−10% of surveyed individuals are aware of physical activity recommendations issued in the USA.[103,104] This alarming finding aligns with other studies demonstrating a lack of evidence knowledge among health and exercise professionals, who represent the key stakeholders prescribing exercise regimes.[34] The panel therefore urges the development of communication strategies to distribute the generated advice using a variety of methods, such as newsletters, social media postings, and collaborations with societies and organizations promoting exercise.

4.3. Limitations

When recruiting the panel of experts, we made a strong effort to make the selection robust to a variety of sources of bias. However, due to a limited number of female researchers with substantial practical background in stretching research, it was not possible to provide a gender and sex balance in the panel. In addition, defining experts—even the criteria to identify them—is to a certain degree subjective. We decided to use a cut-off point of at least 5 authored articles, which, in our view, ensured that a sufficient number of involved researchers with a documented record of expertise in the field could be achieved. Yet, it must be noted that another cut-off point could have altered the composition of the panel. Another issue focuses on the target populations. We provide advice on healthy populations, while patient reviews were excluded from the evidence review. It is hence noteworthy that our recommendations do not necessarily apply to individuals with diseases. With reference to the evidence review, it must be recognized that systematic reviews with or without meta-analysis can only be as meaningful as the evidence summarized in those. Since in some topics, such as injury prevention or cardiovascular health, further research is urgently needed to provide conclusive and meaningful findings, practitioners must note that the presented panel recommendations stem from the available evidence. As in many other areas, scientific research is an ever-evolving process; therefore, practical recommendations can be re-reviewed and extended after new, high-quality evidence is provided in the future. Some potential areas the panel recommends for future exploration are presented in the outlook. Finally, although we followed common guidelines for consensus papers,[36,37,39,40] there are some approaches that suggest reporting information as to how authors specifically disagreed with respect to each topic.[43,44] For transparency and to identify controversial issues, we provided a comment on each statement ("additional remark") reflecting the discussions and issues that need to be considered when reading the recommendations. Notwithstanding, we acknowledge that a more detailed description could have provided interesting insights into the different arguments and the pros and cons discussed.

5. Conclusion

The present Delphi study provides detailed stretching recommendations for practical application (ranging from athletic settings to clinical practice) and precise definitions, which may help practitioners to appropriately select and design related interventions. It also identifies a variety of evidence gaps for future research. The panel recommends stretching for acute and chronic ROM gains (although viable alternatives exists) and to acutely and chronically reduce muscle stiffness (however, this may not be a desirable performance goal). In addition, static stretching may have positive acute and chronic effects on the vascular system, but no strong recommendation can be provided at this point. The panel does not recommend stretching as a primary strategy to achieve chronic strength or muscle mass gains, nor as a strategy to improve post-exercise recovery or promote postural changes. The panel does not recommend stretching for injury prevention in general; there might be an effect in preventing muscle injuries but potentially at the expense of other types of injury (e.g., bone, joint). However, raising awareness about such guidelines may be the most important upcoming task.

Table 2
A collection of outlined needs in stretching research divided into 3 subcategories.

Overall topic	Suggestion
Physiological mechanisms	Fascial/connective tissue adaptations
	Tendon adaptations (understanding potentials harms of acute SSC effects)
	Contralateral effects
	Energy expenditure from stretching
	Neural adaptations
	Moderation of stretching parameters
	Metabolic determinants
Applications in healthy participants	Antagonist stretching effects (chronic)
	Non-local or remote applications
	Postural changes with reasonable stretching durations to moderate structural parameters
	Training methods in highly flexible individuals
	Individual preferences and strategies to enhance commitment
	Time course and sustainability
Clinical applications	Fall prevention
	Injury prevention
	Injury rehabilitation
	Effects on autonomic nervous system activity and sleep quality
	Pathological populations

Abbreviation: SSC = stretch shortening cycle.

Stretching to increase ROM is a well-investigated topic among healthy populations, but for other common applications (e.g., injury prevention, post-exercise recovery) the evidence is either absent or heterogeneous. The consensus is not limited to pre-exercise stretching; existing reviews also include post-exercise stretching, and there seems to be no clear relationship with injury risk. Currently, there is no evidence available to assess the acute effects of stretching on injury risk. This applies to study designs as well, which do not allow for the clear differentiation between acute and chronic stretching effects on injuries. The panel calls for future improvements in research methodology in this topic. Furthermore, a number of stretching applications have barely been explored in the literature. Therefore, the panel calls for future research on the topics provided in Table 2.

Authors' contributions

KW led the process and provided suggestions, collected the responses to ensure blinding for all authors, organized the Delphi rounds until ≥80% consensus was reached, initiated the consensus process and contacted the potential authors for the expert panel, and took the lead in drafting the paper; JW initiated the consensus process and contacted the potential authors for the expert panel, and took the lead in drafting the paper; ET performed the graphical illustrations. All authors were involved in every Delphi step, starting with identifying relevant topics, contributing to the baseline evidence and participating in the individual consensus rounds to find stretching definitions and practical panel recommendations. All authors have read and approved the final version of the manuscript, and agree with the order of presentation of the authors.

Competing interests

The authors declare that they have no competing interests.

Supplementary materials

Supplementary materials associated with this article can be found in the online version at doi:10.1016/j.jshs.2025.101067.

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