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Effects of Muscle Stretching on Muscle Flexibility and Strength: A Literature Review

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Abstract: For numerous years, stretching has been a widely employed technique across various sports disciplines. One of the primary factors influencing the effect on range of motion post-stretching is muscle-tendon stiffness (MTS). Recently, researchers have made groundbreaking discoveries, revealing that stretching can significantly enhance movement range by effectively decreasing MTS. While traditional static stretching has been a staple in warm-up routines, it also appears to adversely impact exercisers' strength performance, raising concerns among athletes and coaches alike. In response to these findings, various studies have introduced alternative stretching forms such as dynamic stretching and proprioceptive neuromuscular facilitation (PNF) stretching, alongside long-term training programs. These innovative approaches aim to optimize the beneficial effects of stretching while mitigating its detrimental outcomes on strength and performance. To comprehensively understand and delineate the immediate and prolonged impacts of both static and dynamic stretching, along with the efficacy of different stretching protocols, this study meticulously examined recent research articles. The objective of this review is to propose a clear terminology and methodology for stretching practices, thereby providing guidance for exercise training and physical activities. By doing so, it seeks to enhance the efficiency and scientific rigor of stretching protocols, ensuring that athletes and fitness enthusiasts can reap the maximum benefits from their stretching routines.

Keywords: Static stretching, dynamic stretching, physical performance, stretching, flexibility, strength

1. Introduction

Stretching involves placing muscles in a passively elongated state for a duration to augment the range of motion (ROM) of joints during physical endeavors and rehabilitation programs. It is now widely accepted that heightened muscle ability of tolerating stretching and decreased passive stiffness of the musculotendinous units contribute to enhanced ROM and diminished reflex activity [1]. Researchers have introduced several stretching methodologies, notably static stretching (SS) and dynamic stretching (DS).

Static stretching typically entails moving a limb to its ROM limit and keep the position for about 15 to 60 seconds. It is a common pre-exercise activity [2] and is also extensively utilized during the post-exercise cool-down phase. The impact of SS on athletic performance prior to exercise remains ambiguous; some studies report beneficial effects [2], while others indicate a decline in performance

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[3]. Research has demonstrated reductions in maximum strength, muscle power, and contractile properties (collectively termed muscle performance) following a single SS session [4]. These alterations can be attributed to both mechanical and neural factors. For mechanical factors, SS elongates and increases the compliance of the muscle-tendon unit (MTU), leading to decreased muscle contraction velocity [5]. Neurologically, SS may diminish nerve impulses and optimal muscle activation [6]. Despite the lack of clarity regarding these potential mechanisms, numerous coaches continue to incorporate SS as a warm-up prior to training sessions. Currently, research is increasingly focusing on alternative stretching modalities, particularly dynamic stretching. In response to these inconsistencies and uncertainties, research is increasingly directing its focus towards alternative stretching modalities, with dynamic stretching emerging as a prominent area of interest.

Dynamic stretching typically involves slow, rhythmic, and controlled repetitions of limb movements within the normal range of motion [7]. Research indicates that dynamic stretching can yield comparable or superior immediate effects on flexibility compared to static stretching. Following dynamic stretching, enhanced "Post-Activation Potentiation" and elevated muscle temperature decrease muscular viscous resistance [1, 7], leading to transient improvements in strength, sprint, and jump performance [5, 8-10]. This stretching modality has proven to be more effective than neither stretching nor static stretching for muscular performance [5]. Consequently, dynamic stretching is now widely incorporated into a common warm-up choice.

2. The immediate impacts stretching muscles on ROM

This review delves into the mechanisms through which stretching enhances range of motion (ROM), as well as the outcomes of studies examining the impact of various stretching techniques on ROM. Across all studies, an elevation in ROM was consistently noted, irrespective of the intensity or application method employed. Furthermore, the research indicated that a single instance of DS and SS displayed no significant difference in augmenting both acute and subacute ROM improvements [11].

Factors such as enhanced tolerance to stretching, reduced MTU stiffness, and decreased reflex activity contribute to the immediate rise in ROM following a stretching session [12]. The immediate increases in ROM after stretching can be attributed to these factors. Notably, the magnitude of ROM enhancement varies with stretching intensity, with higher-intensity static stretching yielding more pronounced gains compared to lower-intensity stretching [13].

Considerable evidence suggests that a brief session of dynamic stretching can elevate ROM around, with effects comparable to those of static stretching [5, 14]. Conversely, other more studies have showed that static stretching is superior to dynamic stretching in improving ROM [15]. These conflicting results may stem from the distinct characteristics of the stretching techniques, which also pose challenges in comparing studies. Specifically, dynamic stretching involves a shorter duration of stretching [1].

3. The immediate impacts stretching muscles on strength

Previous research endeavors have thoroughly investigated the impact of static stretching (SS) on reducing strength production and muscle performance. Specifically, engaging in static stretching for an extended duration, exceeding 60 seconds, has been observed to elicit stretch-induced strength performance deficits during subsequent resistance training sessions [16]. The underlying mechanisms responsible for this phenomenon are multifaceted and intricate, encompassing alterations in tendon stiffness and perturbations in the force–length relationship [17], as well as stretch-induced contractile damage to muscle fibers and a subsequent reduction in electromechanical coupling efficiency [18].

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Conversely, dynamic stretching involves active and repetitive contractions of the muscles to achieve stretching, thereby effectively elevating the muscular temperature [19]. This warming effect facilitates the body's adaptation to the intensity of impending training activities. Consequently, dynamic stretching has garnered significant recommendation as an optimal warm-up routine prior to athletic endeavors such as training sessions or races. This recommendation stems from empirical evidence indicating notable improvements in strength, sprint performance, and jumping abilities following dynamic stretching protocols [8, 9]. Numerous studies have further corroborated the enhancement of strength gains associated with dynamic stretching [10, 20], underscoring its efficacy as a preparatory activity for optimizing muscular performance.

4. Long-term effects of muscle stretching

Regarding long-term stretching, prior research has indicated non-significant effects [20]. A 2018 meta-analysis conducted by Freitas et al., encompassing all forms of stretching, revealed no notable impact on muscle tightness (MTS) following interventions lasting 8 weeks or fewer, irrespective of participants' health status [21]. Randomized controlled trials focusing on long-term dynamic stretching [22] and proprioceptive neuromuscular facilitation stretching [23] similarly failed to demonstrate significant alterations in plantar flexor MTS.

However, upon extending the intervention duration, several studies have observed significant changes in muscle mechanical properties after 12 weeks of static stretching [24, 25]. Specifically, Andrade [26] and Longo [24] reported significant reductions in muscle stiffness and MTS among plantar flexors after a 12-week static stretching program. Moltubakk et al. [25] investigated the effects of a 24-week static stretching intervention and found that passive torque of the plantar flexors, measured at a specific angle, was significantly decreased, indicating enhanced muscle-tendon unit extensibility. Consequently, it appears that static stretching for periods exceeding 12 weeks may effectively reduce MTS.

As a stretching strategy, short periods of static stretching between resistance training groups also showed potential effects on muscle hypertrophy and muscle strength. Mechanically, stretching can modulated anabolic signals by force sensors. Several new studies have shown that intracellular anabolic signaling pathways involved in muscle hypertrophy can be activated under both prolonged contraction and passive stretching conditions under high load [27]. Two 8-week training interventions in untrained men showed that their role in promoting muscle hypertrophy was well validated, even if the evidence for promoting muscle strength was weak [28, 29].

5. Limitations

The stretching effect is influenced by four variables: frequency, duration, holding position, and strength. Controlling and studying the strength and holding position of each stretch presents challenges due to their inherent subjectivity. During literature review, comprehensive comparisons are hindered by these subjective factors and the insufficient information regarding various aspects such as gender, muscle group and warm-up procedures. Furthermore, criteria related to tensile strength, frequency, and duration are neither consistently controlled nor adequately addressed. Additionally, current research, particularly long-term studies, has neglected to fully explore and elucidate the neural adaptation factors associated with exercise. Most studies have concentrated on the acute impacts of static stretching, with limited research on alternative forms of stretching and stretching training conducted at varying intensities and intervention durations.

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6. Conclusion

The extensive review of literature on the effects of muscle stretching on physical performance reveals several key findings. For numerous years, stretching has been a widely employed technique in sports and rehabilitation programs, aiming to augment the range of motion (ROM) of joints. One of the primary factors influencing the effect on post-stretching ROM may be muscle-tendon stiffness (MTS). Researchers have discovered that stretching, particularly dynamic stretching, can enhance movement range by decreasing MTS. However, traditional static stretching (SS) also appears to adversely impact exercisers' strength performance.

Specifically, previous research endeavors have thoroughly investigated the impact of SS on reducing strength production and muscle performance. Engaging in SS for an extended duration, especially exceeding 60 seconds, has been observed to elicit stretch-induced strength loss. These alterations can be attributed to both mechanical and neural factors. Mechanically, SS elongates the muscle-tendon unit, potentially leading to a temporary reduction in contractile properties. Neurally, SS may affect motoneuron excitability and neuromodulation, further contributing to the decline in muscle performance.

In terms of long-term changes, stretching training over 12 weeks can significantly reduce MTS. Some stretching strategies, such as incorporating static stretching between resistance training sets, also showed potential effects on muscle hypertrophy and muscle strength. Mechanically, stretching can modulate anabolic signals by force sensors, activating intracellular anabolic signaling pathways involved in muscle hypertrophy under both prolonged contraction and passive stretching conditions.

Overall, both static and dynamic stretching have a significant improvement effect on ROM. However, static stretching, especially when held for over 60 seconds, has a notable negative impact on muscle strength performance. In contrast, dynamic stretching may yield comparable or superior immediate effects on flexibility and can even lead to transient improvements in strength, sprint, and jump performance. Therefore, when designing stretching protocols for athletic training and physical activities, it is crucial to consider the specific goals, such as enhancing ROM or maintaining muscle performance, and choose the appropriate stretching modality and duration accordingly.

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