Journal of Yoga & Physical Therapy
ISSN: 2157-7595

Commentary
OMICS International

Does Stretching Have Long-Term Effects on Muscle Performance? A Clinical Commentary

Diulian Muniz Medeiros* and Tamara Fenner Martini

Exercise Laboratory Research, School of Physical Education, Physiotherapy and Dance, Federal University of Rio Grande do Sul, Brazil

Abstract

Flexibility is an essential component of physical fitness. The most common technique used to enhance muscle flexibility is stretching. Even though there is a great amount of evidence showing the benefits of chronic stretching on flexibility, it remains unclear whether such increase in flexibility can affect muscle performance (MP). Most of the studies in this field have concentrated in analyzing the acute effects of stretching on muscle strength. However, the literature is scarce with regard to chronic effects of stretching on MP. The possible mechanisms involved in flexibility enhancement following chronic stretching give an indicative that MP might benefit from adequate flexibility. A decrease in muscle-tendon unit (MTU) stiffness seems to be a key aspect for an increase in performance since it might improve the energy storage capacity within the MTU during activities involving stretch-shortening cycle. In theory, it sounds reasonable, but in practice, the relationship between decreased MTU stiffness and increased performance still needs to be better elucidated. Hence, the purpose of the present clinical commentary is to discuss how increased flexibility provided by chronic stretching might affect MP.

Keywords: Flexibility; Athletic performance; Muscle stiffness

Introduction

Flexibility is defined as the capacity of a muscle group to elongate [1]. The most popular strategy used to enhance flexibility is stretching [2], which can be performed either statically [3,4] or dynamically [5]. Stretching is a strategy commonly employed in both training and rehabilitation programs [2] and it is used often in warm-up routines [6]. Nevertheless, a considerable amount of evidence in the last decade has shown that stretching prior to activity may impair performance [7-9]. Hence, elongating a muscle prior to tasks that require maximal performance has been discouraged.

Most review studies in this field have focused their efforts on describing the acute effects of stretching on muscle performance (MP) [8-10]. However, as important as investigating the short-term influence of stretching on MP is analyzing the chronic effects of stretching on MP. Considering that stretching is one of the most common exercise strategies in both recreational and competitive contexts, it is essential that we clarify how an increased muscle length might influence MP. In the present study, MP is defined as the capacity of a muscle (group) to generate force. Normally, MP is assessed by repetition maximum tests [11], isokinetic dynamometry [12] or functional tests (e.g. jumping, sprinting) [13].

There are two main mechanisms that might be responsible for the improvement in MP after chronic stretching. Theoretically, (1) increase in sarcomeres in series might potentiate force-tension relationship [14], and a (2) decrease in muscle-tendon unit (MTU) stiffness is believed to enhance the energy storage capacity in activities involving stretch-shortening cycle [15]. However, the literature in this matter is scarce and heterogeneous, and it remains uncertain how chronic stretching affects MP. Therefore, the purpose of this paper is to discuss the possible mechanisms involved in increased flexibility after chronic stretching in an attempt to elucidate its relationship with MP.

Types of Stretching

There are three main types of stretching that may be performed in flexibility training, static stretching, proprioceptive neuromuscular facilitation (PNF) and dynamic stretching. Static stretching involves reaching a certain ROM and holding the muscle (group) lengthened for a predetermined period of time [16], whereas PNF stretching uses static stretching and isometric contractions of the target muscle in a cyclical pattern [17]. Usually, both static and PNF stretching are preferred in a situation in which the goal is to improve flexibility [18]. Dynamic stretching, which involves the execution of movement patterns throughout the available range of motion (ROM), is more suitable for warm-up routines [5].

Even though there are a considerable number of studies regarding flexibility training, there is no consensus in the literature regarding optimal parameters of stretching. Even the American College of Sports Medicine (ACSM) [19] is quite vague with regard to stretching training prescriptions. The only fact that seems to be widely accepted is that both static stretching and PNF stretching elicit greater enhancements in ROM when compared to dynamic stretching [19]. However, when it comes to parameters of stretching, there is no well-established rule. The ACSM recommends that static stretching should be sustained for 10-30 s two to four times, with higher duration for elderly, from 30-60 s. Regarding PNF stretching, the ACSM suggests 20 to 75% maximum contraction held for 3-6 s followed by an assisted stretching of 10-30 s. They suggest that performing flexibility exercises 2-3 times a week is effective, but daily stretching seems to provide greater gains in flexibility.

Indeed, the parameters of stretching training per se seem not to be a great concern within the studies. To this date, it is still unknown which is the right periodization for flexibility training. The best training volume is uncertain [20] and the proper training intensity is not properly

***Corresponding author:** Diulian Muniz Medeiros, Exercise Laboratory Research, School of Physical Education, Physiotherapy and Dance, Federal University of Rio Grande do Sul, Brazil, Tel: 55 51 99605950; E-mail: Diulian.medeiros@yahoo.com

Received June 09, 2017; **Accepted** July 14, 2017; **Published** July 21, 2017

Citation: Medeiros DM, Martini TF (2017) Does Stretching Have Long-Term Effects on Muscle Performance? A Clinical Commentary. J Yoga Phys Ther 7: 269. doi: 10.4172/2157-7595.1000269

discussed [21]. This makes it difficult to establish the most effective flexibility training protocol to be performed to induce adaptations in the muscle tissue. It is time that we start taking flexibility training more seriously with respect to training periodization. Usually, the only variable that is modified during flexibility training is volume (duration of stretching), whilst intensity is neglected. Recent investigations have shown that stretching intensity is fundamental to muscle tissue adaptation [22,23]. Therefore, it is important that researchers start thinking about stretching intensity accounted by the fact that it might be a key aspect of muscle adaptation.

The Influence of Chronic Stretching on Muscle Flexibility and its Relationship with Performance

In order to comprehend how chronic stretching may affect muscle function, it is critical that we clarify the mechanisms that underpin that increase in flexibility following regular stretching. Normally, there are three main mechanisms used to explain an increase in muscle length: sarcomerogenesis [24,25], increase in stretching tolerance (increase in passive torque at end ROM) [26,27] and decrease in MTU stiffness [28].

Sarcomerogenesis is the addition of sarcomeres in series in a myofibril [29]. It is speculated that regular stretching may induce sarcomerogenesis [25], which potentiates the force-length relationship improving performance during static contractions [14]. However, to this date, there is insufficient evidence of sarcomerogenesis following chronic stretching *in vivo* [30]. Therefore, it becomes hard to consider sarcomerogenesis as a possible mechanism for increased performance following flexibility training. A recent investigation [31] reviewed six studies [26,28,32-35] that evaluated the influence of static stretching training on isometric contractions. The authors observed that none of the included studies showed any improvement in performance after flexibility training using static stretching. If there had been any adaptations within the muscle cell, it is probable that some improvement in performance would have been observed. Indeed, sarcomerogenesis is a real adaptation [24] and it has been observed in animal studies [24] and muscle lengthening approaches [36]. However, the duration and the intensity of the flexibility training necessary to induce such adaptation remain an issue of debate. Future investigations should invest in answering those questions rather than just assessing ROM alone.

An alternative mechanism for increased flexibility following chronic stretching is an increase in stretching tolerance [37]. Several investigations are suggesting that the increased flexibility generally seen after chronic stretching is related to an increased stretch tolerance [26,38,39], which is defined as an increase in passive torque at end ROM observed in the length/tension curve [30]. If there is an increase in ROM, but no shift (to the right) of the length/tension curve is observed, the only reasonable explanation for such enhancement in ROM is modification in the perception of stretching [30], but it remains unknown whether this is a peripheral and/or central adaptation though [30]. Even though the increase in stretching tolerance itself still needs to be better understood, several recent studies using ultrasonography images have established this as a real mechanism for increased flexibility [26,27,38,40]. A recent investigation [41] has proposed that the reason why several investigations have not found a decrease in MTU stiffness following stretching is that there might be an interference of other structures such as nerves and fascia. It is possible that these structures might prevent the stretching of inducing adaptations within the MTU. It should be mentioned in this context that flexibility is an important component of physical fitness and adequate flexibility is inherent in functional movements [42]. Therefore, increase in flexibility even without adaptations in the musculoskeletal tissue is essential to allow proper function [43].

Another possible mechanism for flexibility improvements following stretching is related to viscoelastic adaptations. Viscoelastic materials have an elastic ability, which enables them to store and release energy [44], but they also have a viscous component since their response to tensile force is rate and time-dependent [45]. The viscoelastic variable most evaluated among the studies in this field is passive stiffness, which is the change in passive tension per unit change in muscle length [46]. The literature has demonstrated that decreased passive stiffness may contribute to flexibility improvements after flexibility training [28]. Furthermore, there is some evidence that a decrease in MTU stiffness is associated with increased flexibility [28] and it is believed that a more compliant MTU might enhance the energy storage capacity in activities involving stretch-shortening cycle [15]. A previous investigation [34] has shown that the association of resistance and flexibility training decreases MTU hysteresis more than resistance training alone. Hysteresis is defined as the energy lost as heat during stretching of viscoelastic materials [47]. A decrease in hysteresis following chronic stretching provides an indication that adequate flexibility may improve performance in dynamic activities. However, more high-quality studies are necessary to establish the parameters of stretching needed to effectively decrease MTU stiffness and hysteresis.

Conclusion

Stretching is an important component of both rehabilitation and training routines, but flexibility training programs usually present inadequate periodization. Regardless of the fact that there is a massive amount of studies in this field, it remains unknown what are the most effective stretching parameters to be performed to induce viscoelastic adaptations within the muscle tissue. Considering that decreased muscle stiffness might be essential to enhance MP (especially in activities involving stretch-shortening cycle), it is crucial that we clarify how flexibility training must be performed to achieve that goal.

References

1. Knudson D (2006) The Biomechanics of Stretching. J Exerc Sci Physiother 2: 3-12.
2. Page P (2012) Current concepts in muscle stretching for exercise and rehabilitation. Int J Sports Phys Ther 7: 109-119.
3. Ayala, Franciso, Baranda S De (2010) Effect of 3 different active strech durations on hip flexion range of motion. J Strength Cond Res 24: 430-436.
4. Bandy WD, Irion JM, Briggler M (1998) The effect of static stretch and dynamic range of motion training on the flexibility of the hamstring muscles. J Orthop Sports Phys Ther 27: 295-300.
5. Costa PB, Herda TJ, Herda AA, Cramer JT (2014) Effects of dynamic stretching on strength, muscle imbalance and muscle activation. Med Sci Sports Exerc 46: 586-593.
6. Small K, Mc Naughton L, Matthews M (2008) A systematic review into the efficacy of static stretching as part of a warm-up for the prevention of exercise-related injury. Res Sports Med 16: 213-231.
7. Trajano GS, Seitz L, Nosaka K, Blazevich AJ (2013) Contribution of central vs. peripheral factors to the force loss induced by passive stretch of the human plantar flexors. J Appl Physiol 115: 212-218.
8. Behm DG, Blazevich AJ, Kay AD, McHugh M (2016) Acute effects of muscle stretching on physical performance, range of motion and injury incidence in healthy active individuals: A systematic review. Appl Physiol Nutr Metab 41: 1-11.
9. Kay AD, Blazevich AJ (2012) Effect of acute static stretch on maximal muscle performance: A systematic review. Med Sci Sports Exerc 44: 154-164.

10. Behm DG, Chaouachi A (2011) A review of the acute effects of static and dynamic stretching on performance. Eur J Appl Physiol 111: 2633-2651.

11. Nelson AG, Kokkonen J, Winchester JB, Kalani W, Peterson K, et al. (2012) A 10 week stretching program increases strength in the contralateral muscle. J Strength Cond Res 1.

12. Chen CH, Nosaka K, Chen HL, Lin MJ, Tseng KW, et al. (2011) Effects of flexibility training on eccentric exercise-induced muscle damage. Med Sci Sports Exerc 43: 491-500.

13. Kokkonen J, Nelson AG, Eldredge C, Winchester JB (2007) Chronic static stretching improves exercise performance. Med Sci Sports Exerc 39: 1825-1831.

14. Lieber RL, Bodine-Fowler SC (1993) Skeletal muscle mechanics: implications for rehabilitation. Phys Ther 73: 844-856.

15. Wilson GJ, Elliott BC, Wood GA (1992) Stretch shorten cycle performance enhancement through flexibility training. Med Sci Sports Exerc 24: 116-123.

16. Bandy WD, Irion JM, Briggler M (1997) The effect of time and frequency of static stretching on flexibility of the hamstring muscles. Phys Ther 77: 1090-1096.

17. Sharman MJ, Cresswell AG, Riek S (2006) Proprioceptive neuromuscular facilitation stretching: Mechanisms and clinical implications. Sport Med 36: 929-939.

18. Borges MO, Medeiros DM, Minotto BB, Lima CS (2017) Comparison between static stretching and proprioceptive neuromuscular facilitation on hamstring flexibility: Systematic review and meta-analysis. Eur J Physiother, pp: 1-8.

19. Garber CE, Blissmer B, Deschenes MR, Franklin BA, Lamonte MJ, et al. (2011) Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal and neuromotor fitness in apparently healthy adults: Guidance for prescribing exercise. Med Sci Sports Exerc 43: 1334-1359.

20. Medeiros DM, Cini A, Sbruzzi G, Lima CS (2016) Influence of static stretching on hamstring flexibility in healthy young adults: Systematic review and meta-analysis. Physiother Theory Pract 32: 438-445.

21. Apostolopoulos N, Metsios GS, Flouris AD, Koutedakis Y, Wyon MA (2015) The relevance of stretch intensity and position — a systematic review. Front Psychol.

22. Freitas SR, Mil-Homens P (2015) Effect of 8-week high-intensity stretching training on biceps femoris architecture. J Strength Cond Res 29: 1737-1740.

23. Herda TJ, Costa PB, Walter AA, Ryan ED, Cramer JT (2014) The time course of the effects of constant-angle and constant-torque stretching on the muscle-tendon unit. Scand J Med Sci Sport 24: 62-67.

24. De Jaeger D, Joumaa V, Herzog W (2015) Intermittent stretch training of rabbit plantarflexor muscles increases soleus mass and serial sarcomere number. J Appl Physiol 118: 1467-1473.

25. Zöllner AM, Abilez OJ, Böl M, Kuhl E (2012) Stretching skeletal muscle: Chronic muscle lengthening through sarcomerogenesis. PLoS ONE.

26. Konrad A, Tilp M (2014) Increased range of motion after static stretching is not due to changes in muscle and tendon structures. Clin Biomech 29: 636-642.

27. Konrad A, Gad M, Tilp M (2015) Effect of PNF stretching training on the properties of human muscle and tendon structures. Scand J Med Sci Sport 25: 346-355.

28. Guissard N, Duchateau J (2004) Effect of static stretch training on neural and mechanical properties of the human plantar-flexor muscles. Muscle and Nerve 29: 248-255.

29. Butterfield TA, Leonard TR, Herzog W, Butterfield TA (2005) Differential serial sarcomere number adaptations in knee extensor muscles of rats is contraction type dependent. J Appl Physiol 99: 1352-1358.

30. Weppler CH, Magnusson SP (2010) Increasing muscle extensibility: A matter of increasing length or modifying sensation? Phys Ther 90: 438-449.

31. Medeiros DM, Lima CS (2017) Influence of chronic stretching on muscle performance: Systematic review. Hum Mov Sci 54: 220-229.

32. Akagi R, Takahashi H (2014) Effect of a 5 week static stretching program on hardness of the gastrocnemius muscle. Scand J Med Sci Sport 24: 950-957.

33. Blazevich AJ, Cannavan D, Waugh CM, Miller SC, Thorlund JB, et al. (2014) Range of motion, neuromechanical and architectural adaptations to plantar flexor stretch training in humans. J Appl Physiol 117: 452-462.

34. Kubo K, Kanehisa H, Fukunaga T (2002) Effect of stretching training on the viscoelastic properties of human tendon structures *in vivo*. J Appl Physiol 92: 595-601.

35. Minshull C, Eston R, Bailey A, Rees D, Gleeson N (2014) The differential effects of PNF versus passive stretch conditioning on neuromuscular performance. Eur J Sport Sci 14: 233-241.

36. Boakes JL, Foran J, Ward SR, Lieber RL (2006) Muscle adaptation by serial sarcomere addition 1 year after femoral lengthening. Clin Othopaedics Relat Res 456: 250-253.

37. Magnusson SP, Simonsen EB, Aagaard P, Sørensen H, Kjaer M (1996) A mechanism for altered flexibility in human skeletal muscle. J Physiol 1: 291-298.

38. Konrad A, Tilp M (2014) Effects of ballistic stretching training on the properties of human muscle and tendon structures. J Appl Physiol 117: 29-35.

39. Folpp H, Deall S, Harvey LA, Gwinn T (2006) Can apparent increases in muscle extensibility with regular stretch be explained by changes in tolerance to stretch? Aust J Physiother 52: 45-50.

40. Nakamura M, Ikezoe T, Takeno Y, Ichihashi N (2012) Effects of a 4 week static stretch training program on passive stiffness of human gastrocnemius muscle-tendon unit *in vivo*. Eur J Appl Physiol 112: 2749-2755.

41. Nordez A, Gross R, Andrade R, Le Sant G, Freitas S, et al. (2017) Non-muscular structures can limit the maximal joint range of motion during stretching. Sport Med, pp: 1-5.

42. Rhea MR, Alvar BA, Gray R (2004) Physical fitness and job performance of firefighters. J Strength Cond Res 18: 348.

43. Carregaro RL, Gil Coury HJC (2009) Does reduced hamstring flexibility affect trunk and pelvic movement strategies during manual handling? Int J Ind Ergon 39: 115-120.

44. Böhm H, Cole GK, Brüggemann GP, Ruder H (2006) Contribution of muscle series elasticity to maximum performance in drop jumping. J Appl Biomech 22: 3-13.

45. Peltonen J, Cronin NJ, Stenroth L, Finni T, Avela J (2013) Viscoelastic properties of the Achilles tendon *in vivo*. Springerplus 2: 212.

46. Ryan ED, Beck TW, Herda TJ, Hull HR, Hartman MJ, et al. (2008) The time course of musculotendinous stiffness responses following different durations of passive stretching. J Orthop Sports Phys Ther 38: 632-639.

47. Kubo K (2005) *In vivo* elastic properties of human tendon structures in lower limb. Int J Sport Heal Sci 3: 143-151.

Citation: Medeiros DM, Martini TF (2017) Does Stretching Have Long-Term Effects on Muscle Performance? A Clinical Commentary. J Yoga Phys Ther 7: 269. doi: 10.4172/2157-7595.1000269