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Remote effects of lower limb stretching: preliminary evidence for myofascial connectivity?

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ABSTRACT
The skeletal muscles and the fibrous connective tissue form an extensive, body-wide network of myofascial chains. As fascia can modify its stiffness, strain transmission along these meridians is supposable. The goal of this trial therefore was to collect pilot data for potential remote effects of lower limb stretching on cervical range of motion (ROM). Twenty-six healthy participants (30 ± 6 years) were included in the matched-pairs intervention study. One group (n = 13) performed three 30 s bouts of static stretching for the gastrocnemius and the hamstrings, respectively. An age- and sex-matched control group (CG; n = 13) remained inactive. Pre- and post-intervention, maximal cervical ROM in flexion/extension was assessed. A repeated measures ANOVA revealed systematic differences between groups ($P < .05$). ROM increased following stretching (143.3 ± 13.9 to 148.2 ± 14°; $P < .05$) but remained unchanged in the CG (144.6 ± 16.8 to 143.3 ± 16.8°; $P > .05$). Our data point towards existence of a strain transfer along myofascial meridians. Further randomised controlled studies on conditions, factors and magnitude of tensile transmission are warranted.

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KEYWORDS
Myofascial chains; force transmission; fascia; meridians

Introduction

The traditional mechanistic view of the human body assumes functional coherence but structural independence of the skeletal muscles. Over decades, textbooks and anatomists have conveyed the idea that fascia separates the movement system's active components from each other (van der Wal, 2009). Current evidence challenges the classical assumptions suggesting that fascia links at least a variety of muscles to myofascial chains (Wilke, Krause, Vogt, & Banzer, 2015). The functional relevance of body-wide morphological continuity is a matter of debate. According to findings from animal studies (Schleip et al., 2012; Yahia, Pigeon, & DesRosiers, 1993) and cadaveric trials (Norton-Old et al., 2013; van Wingerden, Vleeming, Snijders, & Stoeckart, 1993; Vleeming, Pool-Goudzwaard, Stoeckart, van Wingerden, & Snijders, 1995), fascia is able to both modify its stiffness and transfer strain to adjacent anatomical structures. Tensile transmission along myofascial chains might contribute to the proper functioning of the movement system. However, despite solid evidence from *in vitro* studies, scarce data is available concerning the *in vivo* behaviour of the meridians.

Grieve et al. (2015) applied a self-myofascial release treatment to the plantar fascia. In response, they observed an increased hip and lumbar spine range of motion (ROM), which might indicate a release of the posterior myofascial chain. Another study (Carvalhais et al., 2013) used a stretching intervention to examine a possible force transfer of the diagonal posterior myofascial chain (m. latissimus dorsi, lumbar fascia, contralateral m. gluteus maximus). The authors found that active lengthening of the latissimus causes an altered resting position and a higher passive resistive torque of the opposite hip joint but did not measure ROM. It is consequently unknown whether stretching can elicit similar remote flexibility gains as self-myofascial release treatments. The present study aimed to address this research deficit by investigating the effectiveness of lower limb stretching to increase neck mobility.

Methods

Sample

Twenty-six healthy participants (30.3 ± 6.2 years; 16 males) were included in the controlled, matched-pairs intervention study which was approved by the local ethics committee. Exclusion criteria encompassed severe orthopaedic, cardiovascular, neurological, psychiatric or endocrine diseases, unhealed injuries and traumas, drug intake in past 48 h, pregnancy and presence of muscle soreness. All participants subscribed informed consent.

Intervention

The superficial back line (myofascial chain consisting of the plantar fascia, m. gastrocnemius, the hamstring muscles and m. erector spinae; Myers, 2001) was selected in order to test its significance as a myofascial pathway. A recent systematic review demonstrated particularly good evidence for the existence of this meridian (Wilke et al., 2015). Based on the course

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Figure 1. Exercises for the intervention consisted of a calf (left) and a hamstring (right) stretch.

of the superficial back line, the intervention group (IG; *n* = 13) performed three consecutive 30 s bouts of static stretching for both the gastrocnemius muscle and the hamstrings, respectively (Decoster, Cleland, Altieri, & Russell, 2005). The exercises were carried out in standing position (Figure 1) and held in a position of mild discomfort. Special care was given not to flex the spine, which was visually controlled by an investigator. For the duration of the stretching exercises, the age- and sex-matched control group (CG; *n* = 13) remained in an inactive sitting position.

Outcome

Prior to and post-intervention, maximal cervical ROM in flexion/extension was assessed in both groups using an ultrasonic 3D movement analysis system (Zebris CMS 70, Zebris Meditechnic GmbH, Isny, Germany). After three familiarisation trials, the participants in a standardised sitting position performed five self-paced maximal movement cycles in the sagittal plane (flexion–extension; Allison & Fukushima, 2003). The used movement analysis system (sampling rate 30 Hz) collects external kinematic data with an accuracy of >.6 mm (Himmelreich, Stefanicki, & Banzer, 1998) and exhibits excellent test–retest reliability (ICC: .86–.95; Williams, McCarthy, Chorti, Cooke, & Gates, 2010).

Statistics

Prior to statistical analysis, data were verified for normal distribution of residuals. A repeated measures ANOVA (2s× 2) and, in case of significance, *post hoc* paired *t*-tests with Sidak-Holm correction were computed to detect potential differences between groups and measurements (significance level was set at $\alpha = .05$). All analyses were performed using SPSS version 22 (SPSS inc., Chicago, USA).

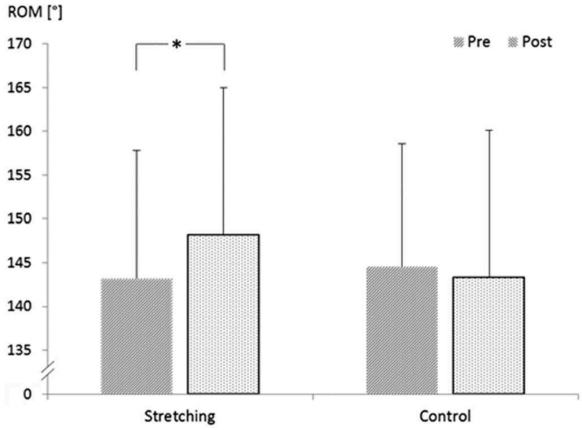

Figure 2. Pre and post results for the stretching and control groups.

Results

At baseline, ROM did not differ in IG and CG ($P > .05$). Following intervention, analysis of variance revealed significant differences between the two disposed conditions ($P < .05$, $d = 1.35$). While the stretching group increased cervical ROM from 143.3 ± 13.9° to 148.2 ± 14° ($P < .05$, $d = 0.33$), it remained unchanged in the CG (144.6 ± 16.8° to 143.3 ± 16.8°; $P = < .05$, Figure 2).

Discussion

Lower limb stretching based on myofascial chains increases cervical ROM. This finding of the present study confirms previous results from cadaveric studies and points towards the existence of strain transmission to distant anatomical structures. Several mechanisms might explain a fascially mediated transfer of tension. Increased tissue hydration and stiffness in response to stretching as well as cellular contractility of fascia have been demonstrated (Bhattacharya, Barooah, Nag, Chaudhuri, & Bhattacharya, 2010; Schleip et al., 2012). In addition, exercise causes a force transmission from the muscle to the surrounding fascia (Findley, Chaudhry, & Dhar, 2015). Local changes, as the described above, could pass over to adjacent structures via myofascial chains. Though our and previous studies (Carvalhais et al., 2013) yield indications, a direct prove for a systemic, connective tissue-related expansion of tension has not been presented so far. This, however, would hold particular significance because other causes for remote exercise effects cannot entirely be ruled out yet. Andrade, Lacourpaille, Freitas, McNair, and Nordez (2015) claim that besides the connective tissue, peripheral nerves also cross multiple joints. They hypothesise that a stretch-induced change in nerve tension might increase stretch tolerance, which in turn enhances ROM. Also, cortical adaptation processes have been suggested to induce remote exercise effects (Behm, Cavanaugh, Quiglex, Reid, Nardi, & Marchetti, 2016).

Regardless of the underlying cause for the effects observed in this study, our results might have implications for therapy of the movement system. Specifically, lower limb stretching represents a viable new therapeutic approach for neck patients, as a restriction in ROM belongs to the broad range of possible symptoms (Garber et al., 2011; Morse, Degens, Seynnes, Maganaris, & Jones, 2008) and as local treatments (e.g., manual therapy) bear the risk of severe adverse events (Kubo, Kanehisa, & Fukunaga, 2002). In general, the occurrence of remote exercise effects provides an additional argument for more holistic treatment approaches incorporating several body regions instead of focusing only on one muscle or the direct localisation of pain. Chronic, excessive strain transmission over myofascial chains could contribute to the development of unspecific pathologies such as back pain or orthopaedic overuse syndromes (Myers, 2001).

Some shortcomings of the present study have to be addressed. Assessment of ROM was performed combining both cervical flexion and extension. Although this approach generates more reliable results than separate measurements (Cagnie, Cools, de Loose, Cambier, & Danneels, 2007), it does not allow a differentiation. The question of whether increases in flexibility were attained in flexion (which would be plausible due to an assumed release of the dorsal muscles) remains unanswered. Another aspect relates to the study design. For this pilot trial, we used a matched-pairs comparison in order to reduce the influence of external variables like age and sex, both of which may impact cervical ROM (Niederer, Vogt, Wilke, Rickert, & Banzer, 2015). Randomised, controlled studies including a larger sample size are warranted in order to further delineate the effects of remote lower limb stretching on cervical ROM. Concomitantly, both peripheral nerves and fasciae as potential mediators of remote exercise effects may be examined in future trials.

Conclusion

The present pilot study demonstrated that a single session of static stretching might elicit acute flexibility increases at distant joints. Strain transfer via myofascial meridians represents a plausible explanation for this finding. However, the influence of other structures such as peripheral nerves cannot be excluded. Further research should be conducted before an evidence-based recommendation for meridian-based stretching can be given.

Disclosure statement

No potential conflict of interest was reported by the authors.

References

Allison, G. T., & Fukushima, S. (2003). Estimating three-dimensional spinal repositioning error: The impact of range, posture, and number of trials. *Spine*, *28*(22), 2510–2516. doi:10.1097/01.BRS.0000090821.38624.D5

Andrade, R. J., Lacourpaille, L., Freitas, S. R., McNair, P. J., & Nordez, A. (2015). Effects of hip and head position on ankle range of motion, ankle passive torque, and passive gastrocnemius tension. *Scandinavian Journal of Medicine & Science in Sports*. doi:10.1111/sms.12406

Behm, D. G., Cavanaugh, T., Quigley, P., Reid, J. C., Nardi, P. S. M., & Marchetti, P. H. (2016). Acute bouts of upper and lower body static and dynamic stretching increase non-local joint range of motion. *European Journal of Applied Physiology*, *116*(1), 241–249. doi:10.1007/s00421-015-3270-1

Bhattacharya, V., Barooah, P., Nag, T., Chaudhuri, G., & Bhattacharya, S. (2010). Detail microscopic analysis of deep fascia of lower limb and its surgical implication. *Indian Journal of Plastic Surgery*, *43*(2), 135. doi:10.4103/0970-0358.73424

Cagnie, B., Cools, A., de Loose, V., Cambier, D., & Danneels, L. (2007). Reliability and normative database of the Zebris cervical range-of-motion system in healthy controls with preliminary validation in a group of patients with neck pain. *Journal of Manipulative and Physiological Therapeutics*, *30*(6), 450–455. doi:10.1016/j.jmpt.2007.05.003

Carvalhais, V. O. D. C., Ocarino, J. d. M., Araújo, V. L., Souza, T. R., Silva, P. L. P., & Fonseca, S. T. (2013). Myofascial force transmission between the latissimus dorsi and gluteus maximus muscles: An in vivo experiment. *Journal of Biomechanics*, *46*(5), 1003–1007. doi:10.1016/j.jbiomech.2012.11.044

Decoster, L. C., Cleland, J., Altieri, C., & Russell, P. (2005). The effects of hamstring stretching on range of motion: A systematic literature review. *Journal of Orthopaedic & Sports Physical Therapy*, *35*(6), 377–387. doi:10.2519/jospt.2005.35.6.377

Findley, T., Chaudhry, H., & Dhar, S. (2015). Transmission of muscle force to fascia during exercise. *Journal of Bodywork and Movement Therapies*, *19*(1), 119–123. doi:10.1016/j.jbmt.2014.08.010

Garber, C. E., Blissmer, B., Deschenes, M. R., Franklin, B. A., Lamonte, M. J., Lee, I.-M., … Swain, D. P. (2011). Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults. *Medicine & Science in Sports & Exercise*, *43*(7), 1334–1359. doi:10.1249/MSS.0b013e318213fefb

Grieve, R., Goodwin, F., Alfaki, M., Bourton, A.-J., Jeffries, C., & Scott, H. (2015). The immediate effect of bilateral self myofascial release on the plantar surface of the feet on hamstring and lumbar spine flexibility: A pilot randomised controlled trial. *Journal of Bodywork and Movement Therapies*, *19*(3), 544–552. doi:10.1016/j.jbmt.2014.12.004

Himmelreich, H., Stefanicki, E., & Banzer, W. (1998). [Ultrasound-controlled anthropometry. On the development of a new method in asymmetry diagnosis]. *Sportverletzung Sportschaden*, *12*(2), 60–65. doi:10.1055/s-2007-993339

Kubo, K., Kanehisa, H., & Fukunaga, T. (2002). Effects of resistance and stretching training programmes on the viscoelastic properties of human tendon structures in vivo. *The Journal of Physiology*, *538*(1), 219–226. doi:10.1113/jphysiol.2001.012703

Morse, C. I., Degens, H., Seynnes, O. R., Maganaris, C. N., & Jones, D. A. (2008). The acute effect of stretching on the passive stiffness of the human gastrocnemius muscle tendon unit. *The Journal of Physiology*, *586*(1), 97–106. doi:10.1113/jphysiol.2007.140434

Myers, T. W. (2001). *Anatomy trains: Myofascial meridians for manual and movement therapists*. Edinburgh: Churchill Livingstone.

Niederer, D., Vogt, L., Wilke, J., Rickert, M., & Banzer, W. (2015). Age-related cutoffs for cervical movement behaviour to distinguish chronic idiopathic neck pain patients from unimpaired subjects. *European Spine Journal*, *24*(3), 493–502. doi:10.1007/s00586-014-3715-y

Norton-Old, K. J., Schache, A. G., Barker, P. J., Clark, R. A., Harrison, S. M., & Briggs, C. A. (2013). Anatomical and mechanical relationship between the proximal attachment of adductor longus and the distal rectus sheath. *Clinical Anatomy*, *26*(4), 522–530. doi:10.1002/ca.22116

Schleip, R., Duerselen, L., Vleeming, A., Naylor, I. L., Lehmann-Horn, F., Zorn, A., … Klingler, W. (2012). Strain hardening of fascia: Static stretching of dense fibrous connective tissues can induce a temporary stiffness increase accompanied by enhanced matrix hydration. *Journal of Bodywork and Movement Therapies*, *16*(1), 94–100. doi:10.1016/j.jbmt.2011.09.003

van der Wal, J. (2009). The architecture of the connective tissue in the musculoskeletal system - An often overlooked functional parameter as to proprioception in the locomotor apparatus. *International Journal of Therapeutic Massage & Bodywork*, *2*(4), 9–23.

van Wingerden, J. P., Vleeming, A., Snijders, C. J., & Stoeckart, R. (1993). A functional-anatomical approach to the spine-pelvis mechanism: Interaction between the biceps femoris muscle and the sacrotuberous ligament. *European Spine Journal*, *2*(3), 140–144. doi:10.1007/BF00301411

Vleeming, A., Pool-Goudzwaard, A. L., Stoeckart, R., van Wingerden, J.-P., & Snijders, C. J. (1995). The posterior layer of the thoracolumbar fascia. Its function in load transfer from spine to legs. *Spine*, *20*(7), 753–758. doi:10.1097/00007632-199504000-00001

Wilke, J., Krause, F., Vogt, L., & Banzer, W. (2015). What is evidence-based about myofascial chains? A systematic review. *Archives of Physical Medicine and Rehabilitation*, *97*(3), 454–461. doi:10.1016/j.apmr.2015.07.023

Williams, M. A., McCarthy, C. J., Chorti, A., Cooke, M. W., & Gates, S. (2010). A systematic review of reliability and validity studies of methods for measuring active and passive cervical range of motion. *Journal of Manipulative and Physiological Therapeutics*, *33*(2), 138–155. doi:10.1016/j.jmpt.2009.12.009

Yahia, L. H., Pigeon, P., & DesRosiers, E. A. (1993). Viscoelastic properties of the human lumbodorsal fascia. *Journal of Biomedical Engineering*, *15*(5), 425–429. doi:10.1016/0141-5425(93)90081-9