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REVIEW ARTICLE

What Is Evidence-Based About Myofascial Chains: A Systematic Review

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Abstract

Objective: To provide evidence for the existence of 6 myofascial meridians proposed by Myers based on anatomic dissection studies.

Data Sources: Relevant articles published between 1900 and December 2014 were searched in MEDLINE (PubMed), ScienceDirect, and Google Scholar.

Study Selection: Peer-reviewed human anatomic dissection studies reporting morphologic continuity between the muscular constituents of the examined meridians were included. If no study demonstrating a structural connection between 2 muscles was found, articles on general anatomy of the corresponding body region were targeted.

Data Extraction: Continuity between 2 muscles was documented if 2 independent investigators agreed that it was reported clearly. Also, 2 independent investigators rated methodologic quality of included studies by means of a validated assessment tool (Quality Appraisal for Cadaveric Studies).

Data Synthesis: The literature search identified 6589 articles. Of these, 62 article met the inclusion criteria. The studies reviewed suggest strong evidence for the existence of 3 myofascial meridians: the superficial back line (all 3 transitions verified, based on 14 studies), the back functional line (all 3 transitions verified, based on 8 studies) and the front functional line (both transitions verified, based on 6 studies). Moderate-to-strong evidence is available for parts of the spiral line (5 of 9 verified transitions, based on 21 studies) and the lateral line (2 of 5 verified transitions, based on 10 studies). No evidence exists for the superficial front line (no verified transition, based on 7 studies).

Conclusions: The present systematic review suggests that most skeletal muscles of the human body are directly linked by connective tissue. Examining the functional relevance of these myofascial chains is the most urgent task of future research. Strain transmission along meridians would both open a new frontier for the understanding of referred pain and provide a rationale for the development of more holistic treatment approaches.

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Treatments of fascial tissues have become increasingly popular in musculoskeletal disorders.[1-5] This might be because of recent histologic findings. The discovery of contractile cells, free nerve endings, and mechanoreceptors suggests that fascia in contrast with prior assumptions plays a proprioceptive and mechanically active role.[6-13] Numerous therapists who address fascia orientate themselves to concepts of myofascial chains. Such approaches originate from the assumption that the muscles of the human body do not function as independent units. Instead, they are regarded as part of a tensegrity-like, body-wide network, with fascial structures acting as linking components. Because fascia can transmit tension,[14,15] and in view of its proprioceptive and nociceptive functions, existence of myofascial meridians could be responsible for disorders and pain radiating to remote anatomic structures. Myers[16] defined 11 myofascial meridians connecting distant parts of the body by means of muscles and fascial tissues (fig 1). The central rule for the selection of a meridian's components is a direct linear connection between 2 muscles. For instance, a part of the superficial back line (table 1) is suggested to be formed by the biceps femoris and erector spinae muscles both being linked by means of the sacrotuberous ligament and lumbar fascia. Even if the biceps femoris also displayed a structural continuity to the gluteus maximus, this connection would not be considered part of the meridian because of its curved, nonlinear course. Although used and referred to in several studies,[17-22] the myofascial meridians are based on anecdotal evidence from practice and have never been verified. Confirming body-wide direct morphologic

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Fig 1 The 6 examined myofascial meridians (from left to right: spiral line, lateral line, front functional line, back functional line, superficial back line, and superficial front line). Adapted with permission. These figures were published in Myers TW. Anatomy trains: myofascial meridians for manual and movement therapists. 3rd ed. New York: Churchill Livingstone; 2014. Copyright Elsevier.

Table 1 Soft tissue components of the included myofascial meridians

Myofascial Meridian	Soft Tissue Components
Superficial back line	• Plantar fascia • Achilles tendon/M. gastrocnemius • Hamstrings (M. biceps femoris, M. semitendinosus, M. semimembranosus) • Sacrotuberous ligament • Lumbar fascia/erector spinae
Superficial front line	• Toe extensors, m. tibialis anterior, anterior crural department • Subpatellar tendon • M. rectus femoris/quadriceps • M. rectus abdominis • M. sternalis/sternochondral fascia • M. sternocleidomastoideus
Back functional line	• M. vastus lateralis • M. gluteus maximus • Lumbar fascia • M. latissimus dorsi
Front functional line	• M. adductor longus • M. rectus abdominis • M. pectoralis major
Spiral line	• Lumbar/erector spinae • Sacrotuberous ligament • M. biceps femoris • M. peroneus longus • M. tibialis anterior • M. tensor fasciae latae, iliotibial tract • M. obliquus abdominis internus • M. obliquus abdominis externus • M. serratus anterior • M. rhomboideus major and minor • M. splenius capitis and cervicis
Lateral line	• M. peroneus longus and brevis, lateral crural compartment • Iliotibial tract/gluteus medius • M. tensor fasciae latae • M. gluteus maximus • M. obliquus abdominis externus and internus • M. intercostalis externus and internus • M. splenius capitis/M. sternocleidomastoid

Adapted with permission from Churchill Livingstone.[16]

continuity between muscle and fascial tissue would therefore yield both an empirical background for such trials and an argument for practitioners to take treatment of complete meridians into consideration. This review aimed to provide evidence for 6 of the myofascial meridians based on anatomic dissection studies.

Methods

The present systematic review adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines.[23] Two independent investigators performed a systematic literature research. The targeted myofascial meridians were the superficial back line, superficial front line, lateral line, spiral line, back functional line, and front functional line (see table 1 and fig 1). For each transition of these meridians, peer-reviewed anatomic dissection studies (published 1900−2014) reporting myofascial continuity between the involved muscles were searched. Animal studies and case reports were excluded; the same applied to articles in languages other than German and English.

Relevant publications were identified using MEDLINE (PubMed; searched with Medical Subject Headings), ScienceDirect, and Google Scholar. Search algorithms for PubMed and ScienceDirect were of more general character (for algorithms see

Table 2 Databases and algorithms for the literature research

Database	Search Algorithm
PubMed	((“cadaver”[Mesh]) AND (“anatomy”[Mesh])) AND (“Fascia”[Mesh]) OR ((myofascial OR aponeurotic OR fascial) AND (continuity OR decussation OR interdigitation OR expansion OR extension))
ScienceDirect	cadaver AND (fascia OR myofascial OR aponeurotic OR fascial) AND (continuity OR decussation OR interdigitation OR expansion OR extension)
Google Scholar	(dissection) AND (“obliquus internus” AND “obliquus externus”) AND (continuity OR expansion OR extension OR fuses OR merges OR blends)

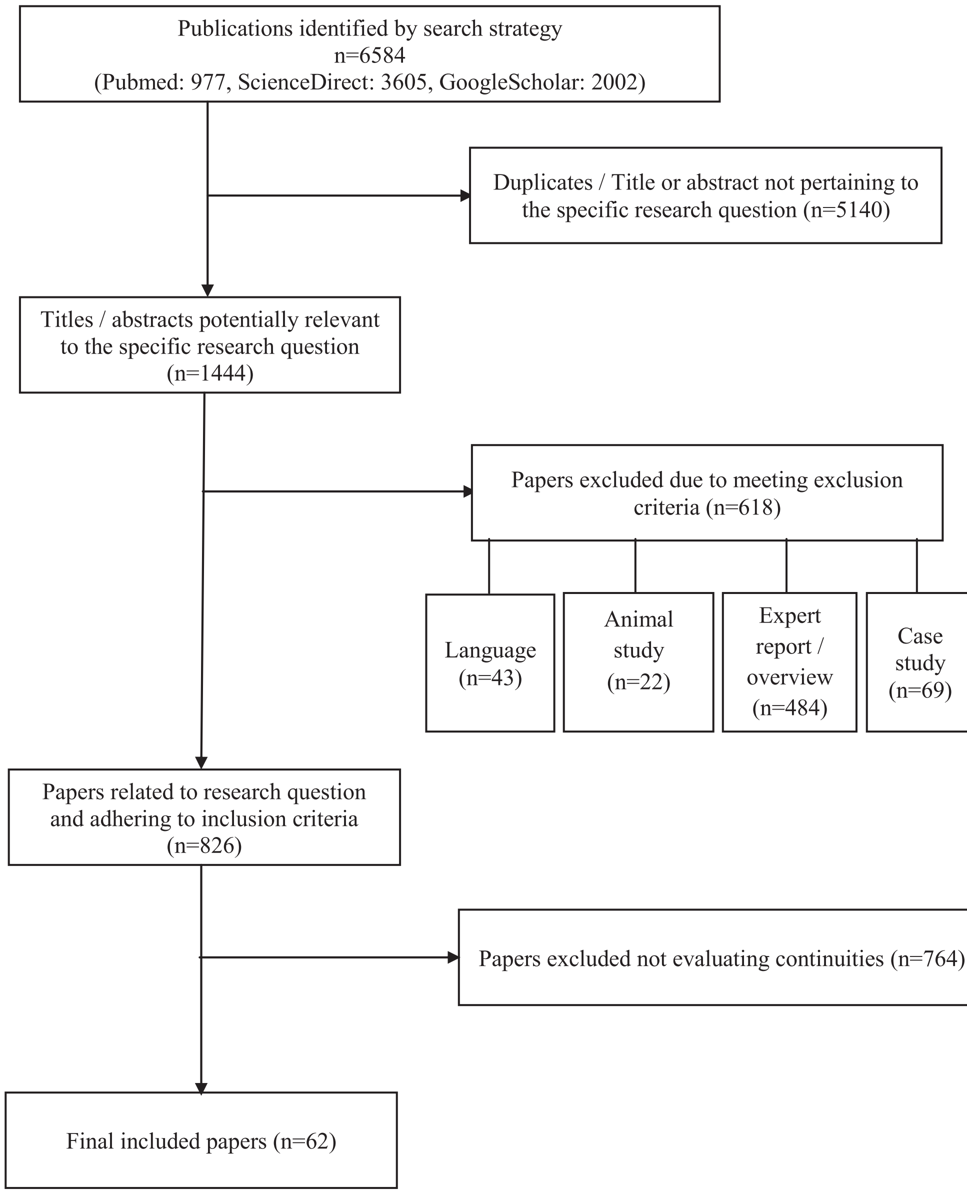

Fig 2 Flowchart displaying the literature research.

table 2), and a more specific free-text search including concrete names of the supposedly connected muscles was performed in Google Scholar. Here, the first 100 hits for each transition of the corresponding meridian were screened. If the initial literature research using the aforementioned procedure with 3 databases did not yield any results for a specific transition, dissection studies describing the general anatomy of the corresponding body region were targeted and screened for the myofascial connection. Additionally, the reference lists of all detected studies were checked. Data extraction was carried out by 2 independent investigators, and a continuity was only documented if both agreed that it was reported clearly.

The methodologic quality of the enclosed studies was evaluated by means of a scale (Quality Appraisal for Cadaveric Studies), which has recently been proven to be a reliable and valid instrument.[24] The scale encompasses a checklist of 13 dichotomous items, and each was scored with either 0 (no/not stated) or 1 (yes/clearly present) point. The quality score is calculated in percent. For the scores, 0% to 20% indicates poor methodologic quality, 21% to 40% indicates fair methodologic quality, 41% to 60% indicates moderate methodologic quality, 61% to 80% indicates substantial methodologic quality, and 81% to 100% indicates excellent methodologic quality. Ratings were done by 2 independent researchers. In case of disagreement, a third reviewer casted the decisive vote. For each meridian and its respective transitions, evidence was classified as strong (consistent findings among multiple high-quality studies), moderate (consistent findings among multiple low-quality studies and/or 1 high-quality study), limited (1 low-quality study), conflicting (inconsistent findings among multiple studies), or not existent (no studies available), according to the recommendations of the Cochrane Collaboration Back Review Group.[25]

Table 3 Included studies and morphologic details for the examined transitions

Myofascial Meridian	Transition	Studies (n)	Consistency	Studies on General Anatomy (n)	Description
Superficial back line	Plantar fascia-gastrocnemius	4 (72)	25/72	NA	Although Kamel,[26] Stecco,[9] and colleagues report continuity in all examined cases, Snow,[27] Kim,[28] and colleagues state that the link diminishes with increasing age.
	Gastrocnemius-hamstrings	5 (57)	51/52	NA	Four studies[29-32] report the semitendinosus to be linked to gastrocnemius, whereas 1 study[33] found a link between the semimembranosus and gastrocnemius.
	Hamstrings-lumbar fascia/erector spinae	5 (122)	BF: 99/122	NA	Martin[34] reports fusion of all hamstrings and erector spinae via the SL. Sato,[35] van Wingerden,[36] Woodley,[37] and colleagues state that the BF blends with the SL in all cases. Vleeming et al[38] report continuity for 41%.
Superficial front line	Toe extensors/tibialis anterior-rectus femoris	0 (NA)	NA	2 (27)	No studies confirming continuity were found. Two studies[39,40] on general anatomy did not yield indications for a morphologic link.
	Rectus femoris-rectus abdominis	0 (NA)	NA	NA	This transition is only mechanical therefore, no literature research was performed for this transition.
	Rectus abdominis-sternalis	0 (NA)	NA	5 (496)	No studies confirming continuity were found. Five studies[41-45] on general anatomy did not yield indications for a morphologic link.
	Sternalis-sternocleidomastoideus	0 (NA)	NA	5 (496)	No studies confirming continuity were found. Five studies[41-45] on general anatomy did not yield indications for a morphologic link.
Back functional line	Latissimus-lumbar fascia	3 (60)	40/40	NA	All 3 studies[46-48] reported the latissimus to fuse with the lumbar fascia at the superficial lamina of the posterior layer.
	Lumbar fascia-gluteus maximus	5 (68)	58/58	NA	Similar to the latissimus, all studies[47-51] reported the gluteus maximus to fuse with the lumbar fascia at the superficial lamina of the posterior layer.
	Gluteus maximus-vastus lateralis	2 (46)	42/46	NA	Although Stern[52] states continuity in all examined cases, Stecco et al[49] observed a fusion of both structures in 2 of 6 specimens.
Front functional line	Pectoralis major-rectus abdominis	3 (51)	51/51	NA	Three studies[53-55] observed fusion of the pectoralis major fascia and the contralateral rectus abdominis in each specimen.
	Rectus abdominis-adductor longus	3 (37)	37/37	NA	According to 3 studies,[15,56,57] a clear continuity of the adductor longus to the contralateral rectus sheath was visible in all examined cases.
Spiral line	Splenius capitis-rhomboideus minor	0 (NA)	NA	2 (19)	Although no study reporting direct continuity was found, Johnson et al[58] indicate a decussation of fibers, and Mercer and Bogduk[59] report collinear orientation of fibers, suggesting a possible fusion of both muscles.
	Rhomboids-serratus anterior	3 (69)	4/4	NA	The fusion of the rhomboideus major and serratus anterior is stated in 3 studies.[60-62] A morphologic connection of the rhomboideus minor is reported only by 2 articles.[61,63]
	Serratus anterior-external abdominal oblique	3 (68)	40/40	NA	The authors of 3 studies[62,64,65] describe intersections or interdigitations of both muscles at the lateral arch of the 5th—10th rib.
	External-internal abdominal oblique	5 (417)	245/245	NA	According to 5 studies,[66-70] the external abdominal oblique sends aponeurotic extensions to the contralateral internal oblique.
	Internal abdominal oblique-tensor fasciae latae	0 (NA)	NA	2 (40)	No studies confirming continuity were found. Also, studies on general anatomy did not yield any indications for a morphologic link.[71,72]

(*continued on next page*)

Table 3 (*continued*)

Myofascial Meridian	Transition	Studies (n)	Consistency	Studies on General Anatomy (n)	Description
	Tensor fasciae latae-tibialis anterior	0 (NA)	NA	3 (90)	No studies confirming continuity were found. Also, studies on general anatomy did not yield any indications for a morphologic link.[73-75]
	Tibialis anterior-peroneus longus	0 (NA)	NA	3 (132)	No studies confirming continuity were found. Also, studies on general anatomy[76-78] did not yield any indications for a morphologic link.
	Peroneus longus-biceps femoris	3 (44)	23/23	NA	El Gharbawy et al[79,80] in 2 studies observed the biceps femoris to send aponeurotic fibers to the lateral surface of the peroneus longus, and Marshall et al[81] describe the middle expansion of the biceps femoris blending with the peroneus fascia.
	Biceps femoris-erector spinae	5 (73)	50/63	NA	As stated for the superficial backline, evidence is conflicting. Although Sato et al[35] report continuity in all cases, Vleeming et al[38] found both structures to fuse only in half of the examined specimen.
Lateral line	Peroneals-iliotibial tract	0 (NA)	NA	2 (47)	No studies confirming continuity were found. Also, studies on general anatomy did not indicate a morphologic link; however, Vieira et al[73] stated that the iliotibial tract extends to the crural fascia.
	Iliotibial tract-gluteus maximus/tensor fasciae latae	5 (61)	NA	NA	Five studies[8,49,50,82,83] found a consistent connection of the gluteus maximus/tensor fasciae latae to the iliotibial tract.
	Gluteus maximus/tensor fasciae latae-abdominal obliques	1 (29)	NA	NA	One study[84] reported the external oblique to fuse with fascia lata whose caudal continuation is tensor fasciae latae.[85] No study stated a link of gluteus maximus to the lateral abdominals.
	Abdominal obliques-intercostals	0 (NA)	NA	2 (80)	No studies confirming continuity were found. Two studies[86,87] on general anatomy did not yield indications for a morphologic link.
	Intercostals-splenius capitis/ sternocleidomastoideus	0 (NA)	NA	2 (80)	No studies confirming continuity were found. Two studies[86,87] on general anatomy did not yield indications for a morphologic link.

NOTE. Values in parentheses are the cumulative number of subjects. Consistency: Continuity observed in share of all cumulative subjects, not reported by all studies.
Abbreviations: BF, biceps femoris; NA, not applicable; SL, sacrotuberous ligament.

Results

The initial literature research yielded 6584 publications. After removing duplicates and articles not pertaining to the research question, exclusion criteria were applied. The resulting sample was comprised of 62 studies (fig 2). The findings for each meridian, including detailed information about characteristics of the appendant transitions, are displayed in table 3. Methodologic quality of the included studies is shown in table 4.

Strong evidence exists for all transitions of the superficial back line (based on 14 studies), back functional line (based on 8 studies), and front functional line (based on 6 studies). With regard to the spiral line (moderate evidence for 5 of 9 transitions, based on 21 studies) and the lateral line (moderate-to-strong evidence for 2 of 5 transitions, based on 10 studies), findings were ambivalent. No evidence from anatomic dissection studies are available for the superficial front line (no verified transition, based on 7 studies).

Discussion

The present systematic review provides relevant information for movement therapists and strength and conditioning coaches. It demonstrates that fascia, besides recently discovered features, such as pain perception and stiffness regulation, connects the skeletal muscles forming a body-wide web of myofascial chains. Extensive structural continuity was clearly verified for 3 of the 6 examined meridians (superficial back line, back functional line, front functional line). In addition, findings were at least ambivalent with respect to the lateral line and spiral line. The fact that we could only confirm half of both lines' transitions does not neglect their existence. Most of the reviewed studies did not specifically search for continuities, mentioning them only as a subordinate finding. Because clinicians and anatomists show increasing interest in fascia, it is well possible that future, more focused research will verify the remaining myofascial links.[88] In contrast with the solid evidence for these 5 meridians, doubts have to be raised about the

Table 4 Number and quality of included studies reporting myofascial continuity between the constituents of the meridians

Myofascial Meridian	Total	Excellent	Substantial	Moderate	Fair	Poor
Superficial back line	14	1	4	7	2	0
Superficial front line	0 (7)	0	(7)	0	0	0
Back functional line	8	1	3	4	0	0
Front functional line	7	3	3	0	1	0
Spiral line	13 (8)	0	2 (3)	10 (5)	1	0
Lateral line	7 (4)	0	6	1 (3)	0	(1)

NOTE. Studies on general anatomy are displayed in parentheses (only searched if no papers reporting continuity were detected).

existence of the superficial front line. There is no structural connection between the rectus femoris muscle and rectus abdominis muscle. Also, the sternalis muscle, which is suggested to be the cranial continuation of the rectus abdominis muscle, exists only in a small percentage of the population.[41-44] Even if present, it does not fuse consistently with the rectus abdominis muscle.[41]

The practical relevance of the present research is 2-fold. First, the existence of myofascial meridians might help to explain the phenomenon of referred pain, which often occurs in nonspecific disorders. For example, myofascial trigger points of the calf have been shown to elicit pain that radiates to the sole of the foot and the dorsal thigh.[89] Because this projection pattern corresponds to the course of the superficial back line, it might represent the morphologic substrate. A second aspect relates to therapy and training of the musculoskeletal system. Direct morphologic continuity between adjacent muscles provides the empirical background to extend diagnostic and therapeutic focus beyond a single anatomic structure. Treatment according to myofascial meridians could be effective in reducing low back pain. Several studies have shown that patients with low back pain display reduced hamstring flexibility.[90-93] Because of the direct morphologic relation of the hamstrings and low back region (both are part of the superficial back line), relieving tension of the posterior thigh muscles could be a conceivable approach to alleviate pain. Overload injuries in competitive sports represent another entity of pathologies which possibly occur because of the presence of myofascial meridians. Recent studies indicate that tightness of the gastrocnemius and hamstrings are associated with plantar fasciitis.[94-96] Because both muscles and the plantar aponeurosis belong to the superficial back line, they might represent a target of exercise therapy. Finally, groin pain or athletic pubalgia is suggested to be provoked by a tight adductor longus and a weak rectus abdominis,[97,98] which according to our results are directly connected in the front functional line. The tightening of the adductor may therefore develop because of communication with the rectus abdominis via the described linkage.

Study limitations

Although our review yields solid evidence for the existence of myofascial chains, several aspects call for further study. Future research should be dedicated to the presence of the meridians, which could not be evidenced entirely in this work. Another issue relates to the function of regional specializations, which so far remains unclear. Depending on its localization, fascia in general exhibits substantial differences concerning thickness, amount of elastic fibers,[11] and adherence to the underlying muscle.[8] Also, the number of connecting fibers is not uniform and shows considerable variation for different transistions.[27] This holds particular significance because the structures linking the muscular stations of the meridians encompass tendinous, aponeurotic, and ligamentous tissue as well as the deep fascia. Finally, it is of utmost importance to elucidate the functional significance of the myofascial chains because the capability for strain transfer represents the decisive criterion to justify treatment of meridians. Although the available evidence points toward existence of tensile transmission via myofascial pathways, most experimental research was carried out in vitro using cadavers.[14,15,36] Randomized, controlled in vivo studies are warranted to draw more precise assumptions on the significance of myofascial chains for the movement system.

Conclusions

Although the concept of myofascial meridians is widely used in exercise therapy and osteopathic medicine, the scientific basis for the proposed connections is still a matter of debate. The present review provides first systematic evidence based on cadaveric dissection studies. Although there is strong empirical support for the existence of the superficial back line, back functional line, and front functional line, evidence is ambivalent with regard to the spiral line and lateral line respectively poor for the superficial front line. Within its borders, the system of myofascial meridians represents a promising approach to transfer tensegrity principles into practice. Therapists may use the myofascial chains as a conclusive orientation, but they should be aware that the functional implications remain to be studied.

Keywords

Connective tissue; Fascia; Meridians; Myofascial pain syndromes; Rehabilitation

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