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The Role of Myofascia in Human Biomechanics: A Systematic Review of the Myofascial Physiology and Dysfunctions

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Abstract

Background: Traditionally viewed as a passive sheath, fascia has been ever since recognized as an active, three-dimensional organ facilitating force transmission and pain migration. Given that musculoskeletal dysfunction and pain remain leading causes of disability, a deeper understanding of myofascial mechanics is crucial.

Aim: This review aims to synthesize current evidence on myofascial physiology, pathophysiology, and the role of fascia in human biomechanics and clinical treatment.

Material and methods: The review synthesizes findings from available anatomical, histological, and biomechanical research, including clinical trials on myofascial therapeutic interventions.

Results: Reviewed data confirms fascia as a continuous network facilitating force transmission through intermuscular connections and myofibroblasts. Key findings point to the relevance of fascial innervation, neuro-sensory feedback, and the effectiveness of manual therapy, instrument-assisted techniques and device-based techniques in treating pain, dysfunction and improving mobility.

Conclusions: Fascia is an integrated biomechanical architecture. Treatment of myofascial disorders requires a complex therapeutic approach targeting entire myofascial chains rather than immediate sites of symptom manifestation.

Keywords: Fascia, Myofascial continuity, Myofascial force transmission, Myofascial meridians, Remote therapeutic effects

1. Introduction

The musculoskeletal system has been widely described based on the direct cause-and-effect premise. Biomechanics is often limited to distinct proximal and distal muscular attachments to the bones and the action of their proximal contraction. Therefore, muscles often function in the general discussion as separate units of movement lacking continuity with other structures. This perceived isolation could stem not only from a simplification of the vast anatomy of the musculoskeletal system, but also from the omission of the key unifying component - myofascia. Although intertwined with muscles, tendons, bones, as well as organs, fascia has been left out of both anatomical education, literally in dissection laboratories, and biomechanical research, reduced to a passive enveloping sheath. What historically has been omitted from discussion in biomechanics of the human body has gained attention in the past decade, pointing to a significant function of myofascia in movement, force transmission and possibly pain migration. This distinction of fascia as a separate organ aiding in movement could open a frontier for understanding and the development of pain management therapies.

2. Defining the Fascial System

The Fascia Research Society defines “fascia” as “*a sheath, a sheet or any number of other dissectible aggregations of connective tissue that forms beneath the skin to attach, enclose, separate muscles and other internal organs*” focusing on a purely anatomical character of fascia. (1,2) However, as research in recent years has pointed to a more complex function of fascia beyond its role as an anatomical connection, the definition for “the fascial system” has been proposed as a *three-dimensional continuum of soft, collagen-containing, loose and dense fibrous connective tissues that permeate the body, providing an environment that enables all body systems to operate in an integrated manner*. This definition allows a more functional view, indicating aspects of fascia including force transmission, sensory functions and wound regulation. Despite the description of fascial continuity, it can be divided into a few distinct layers either found directly under the skin or deeper, enveloping the musculoskeletal system, organs or neural structures. (3) The deep fascia can further be divided into aponeurotic fascia, a distinct fibrous sheet serving as an insertion for broad muscles, while epimysial fascia surrounds skeletal muscles often with an insertion in the periosteum of bones. Indeed, it is the deep fascia that has gained interest in recent years and is the object of growing research.

3. Continuity within the Fascial System

Consistent with the Fascia Research Society's definition of fascial system, the distinction of eleven myofascial chains has been proposed by Thomas Myers (4) Interchangeably myofascial lines or meridians, would be connections within the fascial system of the body, possibly capable of “distributing strain, transmitting force and affecting the structure of the body” Myers approaches the musculoskeletal system as a series of functional, continuous components with fascia as the key unifying factor, as opposed to a traditional view of muscles as units operating independently. (5) The anatomical continuity of myofascial meridians has been ever since attempted to be validated by way of cadaveric investigation. (6)

Six myofascial meridians out of eleven have been questioned, on the basis of proven continuity between adjacent muscles by two independent investigators. A systematic review revealed strong evidence with respect to three myofascial lines, strong to moderate evidence pertaining to two lines, while no verified transition was observed regarding one line.

Table 1. Levels of Evidence of Myofascial Lines and Confirmed Transitions within Myofascial Lines

Myofascial Line	Confirmed Transitions	Level of Evidence
Superficial Back Line	Plantar fascia-M.gastrocnemius	Strong (based on 14 studies)
	M.gastrocnemius-m.semitendinosus, m.semimembranosus	
	Hamstring (m.semitendinosus, m.semimembranosus, m.biceps femoris)-erector spinae	
Back Functional Line	M.latissimus dorsi-lumbar fascia	Strong (based on 8 studies)
	Lumbar fascia-m.gluteus maximus	
	M.gluteus maximus-m.vastus lateralis	
Front Functional	M.pectoralis major-m.rectus abdominis	Strong (based on 6 studies)

Line	M.rectus abdominis-m.adductor longus	
Spiral Line	Rhomboids (m. rhomboideus major, m. rhomboideus minor)-m. serratus anterior	Moderate (based on 21 studies)
	M.serratus anterior-m. external abdominal oblique	
	M.external abdominal oblique-m.internal abdominal oblique	
	M.peroneus longus-m.biceps femoris	
	M.biceps femoris-m.erector spinae	
Lateral Line	Iliotibial tract-gluteus maximus/tensor fasciae latae	Moderate-to-strong (based on 10 studies)
	Gluteus maximus/tensor fasciae latae-abdominal obliques	
Superficial Front Line	None	No evidence (based on 7 studies)

Table 1 excludes theoretical junctions within discussed myofascial meridians that have not been morphologically verified based on aforementioned criteria of exclusion. While all theoretical transitions within the Superficial Back Line, Back Functional Line and Front Functional Line have been validated, the data regarding the Lateral Line and Spiral Line remain inconclusive. No evidence has been shown for 4 out of 9 proposed transitions in The Spiral

Line, while no confirmed continuity has been found in case of 3 out of 5 transitions in the Lateral Line. One of these transitions within the Lateral Line, between peroneals (fibularis longus, fibularis brevis, fibularis tertius) and the iliotibial tract which previously revealed no proven continuity, has been further investigated since. (7) Although there was no direct transition between iliotibial tract and fibularis longus fascia, the iliotibial tract attached uninterruptedly to crural fascia, which displayed strong adhesion to the fibularis longus fascia.

Ascending past the pelvic girdle, into the trunk the fascial network displays a hoop-like architecture as opposed to the linear nature of fascial transitions within extremities. In line with Schuenke et al. abdominal and back muscles are interconnected despite distinct bone insertions via the “lateral raphe” serving as a link between the front and back of the torso. (8) The lateral raphe consists of abdominal myofascial structures (aponeurotic sheaths of transversus abdominis and internal oblique muscles) along with the thoracolumbar fascia, surrounding paraspinal muscles. Moreover, previously excluded from this junction, external oblique muscle fascia has been proven to be in continuity with the thoracolumbar fascia to some extent either through junctions with the latissimus dorsi fascia or direct connection with posterior thoracolumbar fascia. (9) These findings are consistent with Schuenke et al statement that no direct integration of external oblique fibres to thoracolumbar fascia exists, however they also further support the idea of myofascial continuity between the front-lateral and posterior muscles of the torso.

Fascial sequences have also been found in the upper extremity, mirroring those in the lower limb by following an intermuscular pattern of continuity. The overlapping of several conceptual lines within the arm such as the Deep Front Line of the upper limb suggested by Myers (4) prompted research into the anatomical basis of such frameworks. (10)

Muscles involved in the movement of flexion of the arm have been subject to dissection, revealing anatomical continuity in all 15 subjects along the researched transitions, that is pectoralis major to brachial fascia, biceps brachii to antebrachial fascia and palmaris longus to thenaris fascia.

In light of the aforementioned studies, a broader view of the musculoskeletal system emerges, characterized by proven continuity spanning across the system. Consequently, confirming anatomical continuity of fascia is a necessary prerequisite in order to further investigate specific functions and mechanisms of such continuity.

4. Myofascial Force Transmission

The existence of morphological continuity of fascia within the body, although region specific pertaining to some transitions, has been verified in multiple dissection studies and systemic reviews. This information poses a question whether such continuity could be linked to force transmission or distribution of strain. Moreover, considering the connection between topographically distant regions, this prompts an investigation into whether mechanical shifts or strain within the fascial system could manifest itself distally.

The hypothesis of intermuscular force transmission on the basis of fascial continuity relies on the established concept that fascia is mechanically active. (11) Recent histological evidence proves the existence of contractile cells within fascia - myofibroblasts, specialized fibroblasts with contractile properties capable of generating mechanical tension of tissue. (12,13) The density of myofibroblasts and contractile forces of fascia vary across observed tissue such as higher concentration of myofibroblasts in lumbar fascia samples compared to plantar fascia or fascia lata. (11) Schleip et al. suggest that this elevated cellular density might be linked to more significant contractile forces, whereas an absence of myofibroblasts within observed tissue results in no observed contractility. Although the study negates these forces to be significant enough to directly affect mechanical joint stability (specifically of the spine), they are capable of influencing mechanosensation. This in turn, suggests that changes in fascial stiffness could alter proprioception and coordination, predisposing the affected area to injuries.

While fascial tissue indeed does not generate enough force to directly stabilize or move the joint, it is capable of redistributing tension between neighbouring muscles. Huijing et al. investigated the hypothesis of in vivo myofascial force transmission occurring between synergistic muscles of the lower limb: M. gastrocnemius and M. soleus. (14) Utilizing MRI techniques in healthy individuals and dissections of human cadavers, the authors measured local tissue strains during changes in knee position with a fixed ankle joint. Expectedly, altering the knee position directly changed M. gastrocnemius length and caused substantial strain within that muscle. However, measurable strain was also observed within the M. soleus, despite the fixed ankle joint position. Taking into account that the M. soleus does not cross the knee joint, these results imply intermuscular lateral force transmission between these synergists. These findings are in line with previous study on that matter. (15)

A similar mechanism has been observed within the quadriceps complex, where selective elongation of the *M. rectus femoris* alters the mechanical stiffness of the adjacent *M. vastus lateralis* and *M. vastus medialis*. (16)

Along with reports on fascial force transmission in planes perpendicular to the muscle line of action, recent studies have demonstrated longitudinal myofascial continuity, especially within the lower limb.

Cruz-Montecinos et al. demonstrated that pelvic tilt strongly correlates with deep fascia displacement within the remote *M. gastrocnemius* and confirming a descending pathway of tension propagation. (17) Conversely, this longitudinal mechanism also functions along an ascending pathway, as demonstrated by Wilke et al. (18) Their work showed that passive ankle dorsiflexion is capable of displacing the proximal *M. semimembranosus*, proving the reciprocal propagation of tensile stress along the dorsal myofascial chain of the lower limb.

Given the small sample size of that study and the lack of a control condition with a flexed knee, these gaps were subsequently supplemented by data from a later trial. (19) These new data aligned with previous claims, further solidifying the original hypothesis.

To date, the majority of available data on myofascial force transmission remains focused on the tension propagation within the lower limb both laterally and longitudinally. These gaps could potentially be explained by the strongly established knowledge of myofascial connections within the lower limb, as well as the fact that this specific anatomical location allows for accessible measurement of such stresses. While the precise measurement of tension propagation within the trunk remains challenging due to the inherent difficulty of isolating specific muscles, a recent study addressed this gap by focusing on the potential for stress transfer via the thoracolumbar fascia. (20) Carvalhais et al. observed that both active and passive *M. latissimus dorsi* tensioning led to the recruitment of the contralateral *M. gluteus maximus*, therefore shifting the hip resting position towards lateral rotation. These findings provide empirical evidence for a cross-diagonal force propagation pathway across the shoulder girdle, trunk, pelvis, and lower extremity through the thoracolumbar fascia.

Elaborating on this cross-diagonal mechanism of fascia, a recent study attempted to display the link between sacroiliac joint dysfunction and shoulder girdle kinematics. (21) This association aligns with the premise established in the former study regarding a connective tissue linkage between the sacroiliac and glenohumeral joints, thereby implying a corresponding pathway for myofascial force transmission. (20) These pathways follow diagonal myofascial continuities -

specifically the anterior sling, which connects the *M. pectoralis major* to the contralateral pubic bone, and the posterior sling, which connects the *M. gluteus maximus* to the contralateral humerus via *M. latissimus dorsi*.⁽²²⁾ The functional stability of the glenohumeral joint relies on force generation from both slings, provided that the net moment of these forces equals zero. Any impairment in force generation within one sling, such as during sacroiliac joint dysfunction, destabilizes this equilibrium and leads to further biomechanical dysfunction in topographically distant regions along the pathway.

Joseph et al. confirmed this hypothesis, observing that individuals with sacroiliac joint dysfunction exhibited increased anterior translation of the humeral head compared to the control group, suggesting tension dominance of the anterior oblique sling in light of impaired posterior oblique sling and loss of antagonist counter-torque. This study sheds light on a crucial aspect of fascial mechanics, shifting the perspective from direct, linear force propagation to a spatial continuum, where underactivity in a certain region can manifest distally in seemingly unrelated topographical locations. These findings, along with other evidence of force transmission within fascia, could open a new frontier for understanding myofascial pathologies, ultimately reshaping clinical frameworks toward holistic approaches that address the root mechanical cause rather than solely treating localized symptoms.

5. Clinical Significance of the Fascial Network

The clinical significance of myofascia lies in its ability to function as a standalone organ capable of propagating tension, but also playing a significant role in proprioception and sensory perception, thereby modulating the biomechanics of the musculoskeletal system. Defining the physiology and, more importantly, the pathophysiology of myofascia introduces a new outlook on disorders previously believed to be caused mainly by muscle discrepancies, and therefore treated solely within localized pain manifestations. Indeed, one of the most common chronic musculoskeletal disorders - Myofascial Pain Syndrome (MPS) was first explained primarily by muscular dysfunction, despite localized treatments not bringing the desired results. ⁽²³⁾Hence, viewing myofascia as more than a “mere protective sheath”, but as an organ whose dysfunctions could have significant clinical manifestations, is crucial for developing accurate diagnostics and effective therapeutic strategies. Despite the multifaceted nature of pathologies within fascia, the most frequent and simultaneously most non-specific clinical manifestation is pain.

Notably, recent literature suggests that fascia is the second most highly innervated tissue after the skin, containing neural structures responsible for both nociception and proprioception. (24,25) Indeed, certain regions within the fascial network display a heightened density of free nerve endings across healthy individuals, indicating distinct anatomical hotspots dedicated to neuro-sensory feedback. Stecco et al. confirmed the presence of both free nerve endings and encapsulated mechanoreceptors, specifically Pacinian and Ruffini corpuscles, although their distribution varies across anatomical regions. Furthermore, multiple studies have demonstrated a greater subjective pain perception in response to fascial stimulation compared to intramuscular stimulation. The application of hypertonic saline or electrical stimulation directly to the fascia in healthy individuals elicited descriptions of pain as “torturous” and “agonizing”, while the same stimulation applied strictly to the adjacent muscle tissue did not produce the same reaction.(26,27) These findings suggest a greater contribution of fascial structures to non-specific pain disorders than previously recognized. In addition, a higher density of free nerve endings has been found in pathological fascia compared to healthy tissue, pointing to a process of peripheral nociceptor sensitization and neural sprouting in response to chronic tissue dysfunction.(28,29) The driver behind pain disorders within fascia is a chain of complex biomechanical reactions within the structure of fascia. The basis of healthy fascia lies on physiological elasticity of fascia and sliding of its layers or between fascia and the epimysium of muscles

The driver behind fascial pain disorders is a complex mechanism of biomechanical and biochemical reactions within the tissue architecture. The basis of healthy fascia relies on its physiological elasticity, tissue hydration, and the uninterrupted sliding between its layers, as well as between the fascia and the muscle epimysium. Prolonged immobility within specific tissues, such as static desk sitting, extended bed rest, or protective muscle guarding can lead to increased viscosity between fascial layers via the self-association of hyaluronan chains within the extracellular matrix. (30)This increased viscosity leads to impaired gliding of fascial layers, stiffness and, ultimately, a reduced range of motion within the affected area.

Moreover, past a certain threshold of viscosity, even physiological stretching can elicit pain signals as the embedded free nerve endings become hyper-activated. (31) Moreover fascia is subject to structural remodelling both physiological in response to acute injury, and pathological fibrosis, characterized by excessive collagen matrix deposition. The process of fibrosis is the result of chronic inflammation following prolonged or repetitive strain, affecting the capacity of load transmission.(32) As of today, the main diagnostic tools used in fascial

pathology imaging are limited mainly to ultrasonography and MRI, aimed at assessing fascial stiffening, thickening, and gliding. Various ultrasonography methods provide promising results in differentiating fascial pathologies, namely B-mode ultrasonography, dynamic ultrasonography, and shear wave elastography. (33)

The distinction between the processes driving fascial disorders is crucial for proper treatment application. Changes tied to viscosity alterations can be resolved via manual shear strain, which is suspected to improve a patient's condition by catalysing a self-limiting inflammatory reaction through the breakdown of hyaluronan chains, therefore explaining the post-treatment soreness observed after manual therapy.(31,34) Additionally, it is hypothesized that localized temperature increases generated during treatment aid short-term relief, as hyaluronan chain breakdown thereby viscosity reduction become particularly prominent at temperatures approaching 40°C. Ultimately, viscosity changes are considered easier to resolve than macroscopically appreciated structural alterations, in contrast with fibrosis which resolves only in case of local inflammatory process. (35)As transient densification is likely to progress to fibrosis, it is postulated that early prevention measures, namely early guided mobilization is essential to proper healing of damaged fascia. (36)

6. Treatment

The most widespread treatment of fascial dysfunction as of today is manual therapy, utilizing different techniques depending on the intensity and covered area. These techniques in contrast to motion of rhythmic kneading in traditional massage targeting muscles, uses sustained pressure or stretching, oftentimes alongside breathing techniques. (37) Although most studies reviewing the effectiveness of myofascial release techniques do not provide information on long term improvements, significant short-term improvement has been observed across multiple trials. Interdisciplinary fascial therapy combining myofascial trigger point release method and paced breathing training, has been shown to significantly reduce pain sensation and perceived disability in subjects with chronic back pain. (38) Along with pain reduction, manual therapy has also been proven to reduce thickness of the fascia, when measured utilizing ultrasonography. Although the degree of thickness reduction ranges from modest to significant, presumably depending on technique intensity, it is hypothesized that myofascial release techniques influence inter-layer viscosity changes. (39,40)

In contrast, instrument assisted techniques may target localized fibrotic regions within fascia, since these methods allow for a more focal mechanical loading. Instrument assisted soft tissue

massage (IASTM) has grown in popularity in the last years, as a method where clinicians utilize rigid tools in a scraping motion across patient's affected tissues. IASTM reinitiate inflammatory processes in the affected tissue via micro trauma, which allows for remodelling, proving especially useful in degenerative, fibrotic sites in fascia. (41) Recent studies revealed IASTM to be effective not only in pain management, but also in increasing the range of motion and flexibility of the treated area, yielding better results than static stretching or foam rolling. (42,43)

Considering potential restricted access to physiotherapy and trained clinicians, self-myofascial release (SMR) techniques such as foam rolling, roller massagers or massage balls may offer a practical alternative, despite relatively modest and short-term benefits. However, as Behm et al. (2019) argue, the term 'release' is likely a misnomer, as self-applied manual forces are insufficient to physically break down fascial adhesions. Therefore, it is instead postulated, that these interventions yield benefits by modulating neuro-sensory feedback and fluid dynamics (44) Findings on the effects of SMR vary across studies, with some indicating non-significant gains, however the majority report acute improvements in range of motion, reduced delayed onset muscle soreness (DOMS) following physical activity. (45) Evidence on chronic effects of SMR techniques remains inconsistent. It is however challenging to accurately evaluate the effects of SMR, due to considerable study heterogeneity, specifically variations in applied pressure, technique, and intervention duration across trials and individuals.

Consistent with hypothesized myofascial continuity and myofascial meridians, some studies revealed effects remote to the site of therapeutic intervention. Simatou et al. found that IASTM therapy applied to the trunk or lower extremity along the Lateral Line, increased hip mobility irrespective of the application site. (43) Similar findings have been reported by Fousekis et al. in regards to the Superficial Back Line (SBL) where regular treatment of the upper or lower part of the SBL increased hamstring flexibility regardless of initial site of therapy. (46) Aforementioned research highlights the possible need for complex therapy, targeting not only the immediate site of symptom manifestation but also the broader myofascial connections contributing to the dysfunction.

Device-based techniques, particularly extracorporeal shock wave therapy (ESWT), have shown promising results for fascial remodelling by stimulating fascial fibroblasts therefore inducing the synthesis and release of collagen fibres and hyaluronan. Moreover, these results have been observed to be present at one hour mark as well as for up to 24 hours, with clinical studies demonstrating significant improvements up to three months post-treatment.

Consistent with the concept of myofascial continuity and myofascial meridians, several studies have revealed remote therapeutic effects located far from the intervention site. For instance, Simatou et al. demonstrated that IASTM applied along the Lateral Line, at either the trunk or lower extremity, increased hip mobility irrespective of the specific application site (40). Similar remote effects were reported by Fousekis et al. regarding the Superficial Back Line (SBL), where targeted treatment applied to either the upper or lower segment of the SBL enhanced hamstring flexibility regardless of the initial site of therapy (43). Altogether, this research highlights the necessity for a comprehensive therapeutic approach that addresses not only the immediate site of symptom manifestation, but also the broader myofascial chain contributing to the underlying dysfunction

7. Conclusions

This review highlights that the fascial network functions as an integrated system, rather than a passive enveloping sheath. Presented research proves that fascia spans continuously throughout the human body, acting as an integrated biomechanical architecture facilitating force and strain transmission. The presence of various innervation and contractible myofibroblasts within it further supports the view that fascia partakes in body biomechanics and neurofeedback mechanisms. Given the distinction of fascial dysfunctions, such as increased interlayer viscosity and fibrosis, it is justified to incorporate interventions matched to the specific dysfunction. Furthermore, considering the distant manifestations of fascial dysfunctions, it is recommended to adopt a holistic therapeutic approach in myofascial disorders. Available therapeutic methods involve manual therapy, instrument-assisted soft tissue massage (IASTM), and device-based techniques. As treatment methods range in mechanism of action, targeted area, and therefore its effects, it is recommended to apply patient-specific and often complex strategies incorporating a few treatment methods.

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