

Understanding Muscular Chains – A Review for Clinical Application of Chain Stretching Exercises Aimed to Correct Posture

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Abstract

Françoise Mézières was one among the pioneers to talk about the concept of muscular chains and to use it as a treatment. Through further observations, she developed the Mézières method—a way to stretch at the same time all the muscles contained in a group she called muscular chain. Her students created their own methods based on hers, changed her chains, and added more muscles. At the same time, other approaches have been created by authors with other backgrounds. Because of the numbers of chains and the differences between them, this article aims to review and compare these chains. Another objective is to understand which of the muscle chain models are more sustained by anatomy and biomechanics and what would be the best model for chain-stretch exercises. Of the six authors reviewed, the approach made by Myers is the most reliable. It is advisable to use his model for application of myofascial maneuvers aiming to improve the posture. However, for a chain-stretching work, a different approach is necessary. This approach can be made based on Myers' lines and also have correlations with the other methods reviewed. In the present study, there is the discussion regarding its importance, a functional approach, and the rules to build it based on Myers' anatomy trains.

Keywords: Mézières Method; Muscular Chains; Posture; Stretching; Anatomy Trains

Introduction

Françoise Mézières was one among the pioneers to talk about the concept of muscular chains and to use it as a treatment [1]. The way she discovered the muscular chains and their influence on posture was very interesting. She received a patient with an important kyphosis complaining about impossibility of raising the arms. Strengthening and stretching were not showing any effect because of the strong rigidity. Laying the patient down in supine and pressing the forward shoulder down produced an enormous hyperlordosis. However, while standing, the patient just displayed the kyphosis. Bringing the knees toward the chest worked fine to solve the lordosis problem. Nevertheless, the thoracic hyperlordosis moved to the neck with this position. With this patient, she started to understand that all partial shortening of the back muscles produced a functional shortening in several back muscles [2].

Based on further observations, she developed the Mézières method—a way to stretch at the same time all the muscles contained in a group she called muscular chains [1]. Her students created their own methods based on hers, changed her chains, and added more muscles.

Ida Pauline Rolf developed another interesting method called structural integration, also known as Rolfing [3]. Her method also works with body alignment. However, instead of treating muscles, this method focuses on the fascia. One of her students, Myers [4] presented an anatomical study of myofascial chains.

Piret and Bezières [5] were among the first authors to explain the mechanics of the crossed or spiral chains. Their ideas were influenced by Herman Kabat and the diagonal patterns of his method, called proprioceptive neuromuscular facilitation [6]. Some of Mézières's students, based on the writings of Piret and Bezières, created their own crossed chains [7-9]. Myers [4], with his different point of view earned from his Rolfing background, developed a similar chain while studying the fascial connections throughout the body.

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Besides the crossed chains, there is also the lateral chain, a straight chain that the majority of the authors have almost forgotten. While some components of the lateral chain may be described by some [7-12], only two authors described it isolated [4,13].

In view of the numbers of chains and the differences between them, this article aims to review and compare these chains. Another objective is to answer the following questions:

1. Which of the theories are more sustained by anatomy and biomechanics?
2. What would be the best model for chain-stretch postural exercises?

It is important to remember that the chains exist for postural correction. Thus, any chain that can be used to adjust posture can be compared. In this article, one myofascial chain [4] and one muscular chain with some fascial elements [8,9] have been compared to four pure muscular chains [1,7,11-14] only at the muscular level, which is common to all of the chains.

Materials and Methods

Books and articles with muscular chain descriptions written by heirs of the Mézières method [7-9,11,12,14,15] and Myers' anatomical trains [4] were reviewed. All the muscles used by all of these methods were divided in five different tables: anterior, posterior, arm chains, lateral chains and crossed chains. Thus, it makes possible to visualize the differences and similarities among them based on anatomical structures. The Godelieve Dennys-Struyf method has been abbreviated as GDS. The fascial structures were not used in this review because the majority of the authors cite only muscular components. Besides, the table would have too many values, confounding the reader. On the other hand, fascial structures were included on the discussion session when important.

Other relevant books and articles cited by the authors or helpful in explaining a biomechanical, anatomical, or functional aspect of the chains were also used.

Results and Discussion

Results

The first chain to be analyzed is the one passing at the back with a general tendency of provoking extension and lordosis (Table 1, Figure 1). Although Mézières [14], Souchard [15] and Rosario [6,10] give the same name to this chain, GDS uses posteromedian, whereas Myers uses superficial back line. Busquet [8,9] has two chains in this part of the body: the extension chain and the static posterior chain. There are some curious facts about this two chains. The extension chain, like all others, is located in the posterior part of the body. However, in a descendent way, after passing the gluteus maximus, it goes to the front part of the body, passing through the quadriceps. At the knee level, it comes back again toward the soleum. The static posterior chain is mainly composed of the connective tissue (bones and ligaments) and just one muscle (tensor fasciae latae).

The second chain to be analyzed passes in the frontal part of the body (Table 2, Figure 1). It has a tendency of flexion and kyphosis. Busquet [8,9] is the only author with just one chain, naming it flexion chain. Similar to his extension chain, this one changes direction after the rectus abdominis, passing through the pelvic floor, semimembranosus, and after popliteus, it comes back to the front with the extensor digitorum longus.

GDS has the anteromedian and the posteroanterior-anteroposterior [7]. The last one is an intermediary between anterior and posterior. It is in the anterior section because it has more anterior than posterior components. Souchard has two complementary chains: inspiratory and hip chains [15]. Myers [4] also has two chains: superficial front line and deep front line. Myers' deep front line goes to the back part of the body on the knee level, passing from the hip adductors to the tibialis posterior and finger flexors, whereas the superficial front line keeps straight to the tibialis anterior and toe extensors. Rosario [6,10] has the anterior and the head chains and Mézières [14] has the anterointerior and neck anterior chains.

	Mézières	GDS	Rosario	Busquet	Myers	Souchard
	Posterior Chain	Posteromedian Chain	Posterior Chain	Extension (E) and Static Posterior (SP) chains	Superficial Back Line	Posterior Chain
Rectus capitis posterior minor	X		X			
Rectus capitis posterior major	X		X			
Obliquus capitis superior	X					
Obliquus capitis inferior	X					
Semispinalis capitis	X	X	X			X
Longuissimus capitis	X	X	X		X	
Longus capitis						X
Longus colli	X					X
Splenius capitis	X		X			X
Spinalis capitis		X	X	E	X	
Splenius cervicis	X		X			X
Semispinalis cervicis	X		X			X
Spinalis cervicis	X	X	X	E	X	X
Iliocostalis cervicis	X	X	X		X	X
Longuissimus cervicis	X	X	X	E	X	X
Sternocleidomastoid	X					
Trapezius	X			E (lower fibers)		
Teres major				E		
Spinalis dorsi	X	X	X	E	X	X
Iliocostalis dorsi	X	X	X		X	X
Semispinalis dorsi	X		X			X
Longuissimus dorsi	X	X	X		X	X
Iliocostalis lumborum	X	X	X	E	X	X
Spinalis	X	X				
Levator costae				E		
Serratus posterior superior	X			E		
Serratus posterior inferior	X			E		
Intertransversarii	X		X			X
Interspinales	X		X			X
Rotatores			X			X
Multifidus			X			X
Transversospinalis	X			E		
Gluteus maximus	X		X	E		X
Gluteus medius	X					
Gluteus minimus	X					
Lateral rotator group	X					

Quadratus femoris				E		
Semimembranosus	X	X	X		X	X
Semitendinosus	X	X	X		X	X
Biceps femoris	X		X		X	X
Tensor Fascia latae	X			SP		
Vastus intermedius				E		
Rectus femoris				E		
Popliteal	X		X			X
Gastrocnemius	X		X		X	X
Soleus	X	X	X	E		X
Flexor digitorum longus	X	X	X			X
Flexor hallucis longus	X	X	X			X
Flexor digitorum brevis		X	X	E	X	X
Flexor hallucis brevis		X	X	E	X	X
Adductor hallucis			X			X
Abductor hallucis			X			X
Extensor digitorum brevis				E		
Interossei muscles				E		

Table 1: List of muscles of the posterior chain. Mézières, Souchart and Rosario name this chain as posterior, posteromedian for GDS and superficial back line for Myers. Busquet has two distinct chains in the back: extension (E) and static posterior (SP) chains.

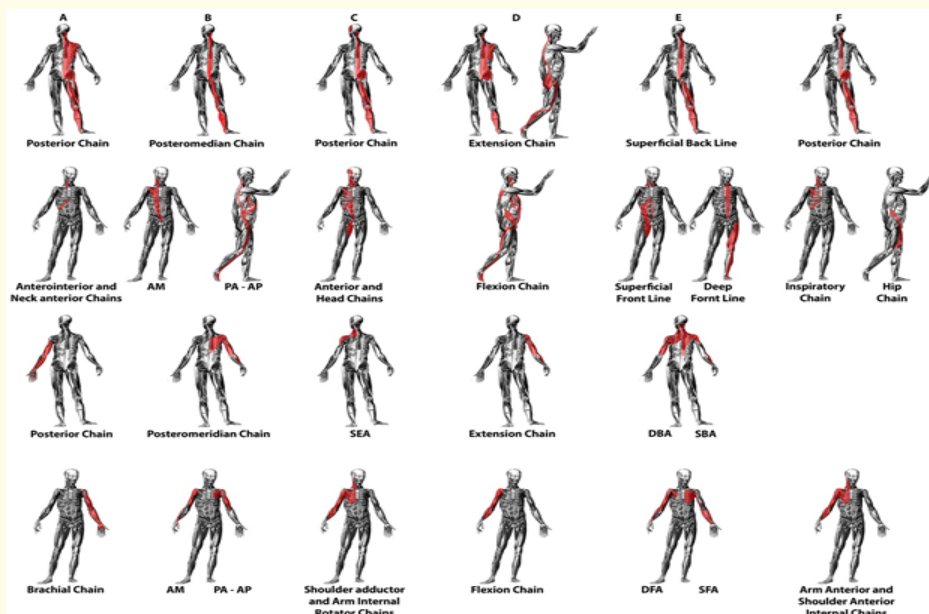


Figure 1: Visual comparison among all the chains. The first row contains all the posterior chains. Second row contains anterior chains. Last row displays arm chains. There are the Mézières Chains at column A; GDS chains at column B; the Rosario chains at C; the chains of Busquet at D; Myers lines at E; and the Souchart chains of at F.

	Mézières	GDS	Rosario	Busquet	Myers	Souchard
	Anterointerior (AC) and Neck Anterior Chains (NAC)	Anteromedian (AM) and Posteroanterior Anteroposterior (PA-AP) Chains	Anterior (A) and Head (HC) ChainS	Flexion Chain	Superficial front (SF) and deep front (DF) LineS	Inspiratory (IC) and Hip (HC) Chains
Temporalis			HC			
Pterigoideus medialis			HC			
Pterigoyd lateralis			HC			
Masseter			HC			
Hyoid muscles		AM	HC		DF	
Rectus capitis anterior	NAC					
Splenius capitis		PA-AP				
Longus capitis	NAC				DF	
Splenius colli		PA-AP				
Longus colli	NAC				DF	
Diaphragm	AC	PA-AP	A		DF	IC
Scalene		AM – PA-AP	A		DF	IC
Sternocleidomastoid		AM	A		SF	IC
Subclavius		AM				
Teres major				X		
Rhomboidei				X		
Trapezius				X		
Levator costae		PA-AP				
Intercostals		AM - PA-AP	A	X		IC
Deep paravertebral muscles		PA-AP				
Sternalis					SF	
Pectoralis minor			A	X		IC
Pectoralis major		AM		X		
Transversus thoracis		AM		X	DF	
Rectus abdominis		AM	A	X	SF	
Transversus abdominis		PA-AP				
Quadratus lumborum		PA-AP				
Levator ani		AM		X	DF	
Coccygeus		AM		X		
Iliacus	AC	PA-AP	A	X	DF	HC
Psoas major	AC	PA-AP	HC	X	DF	A
Psoas minor	AC	PA-AP	HC	X	DF	A
Vastus Medialis		PA-AP				
Rectus femoris		PA-AP			SF	A

Quadriceps					SF	
Gemellus				X		
Obturator				X		
Pectineus			HC		DF	A
Gracilis			HC			A
Adductor magnus			HC		DF	A
Adductor brevis			HC		DF	A
Adductor longus			HC			A
Adductor minimus					DF	
Semimembranosus				X		
Popliteus				X		
Tibialis anterior					SF	
Tibialis posterior					DF	
Extensor digitorum longus		PA-AP		X	SF	
Extensor digitorum brevis		PA-AP			SF	
Extensor hallucis longus		PA-AP			SF	
Extensor hallucis brevis		PA-AP			SF	
Flexor digitorum longus					DF	
Flexor hallucis longus					DF	
Lumbricales				X		
Quadratus plantae				X		
Flexor hallucis brevis				X		
Flexor digiti minimi brevis				X		

Table 2: List of muscles of the anterior chain. Mezieres has the anteroanterior (AC) and neck anterior (NAC), GDS has the anteromedian (AM) and the posterioranterior anteriorposterior (PA-AP). Rosario uses anterior (A) and head chain (HC), Busquet uses the name flexion, Myers uses superficial front line (SF) and deep front line (DF), and Souchard has the inspiratory (IC) and hip (HC) chains.

The third chain to be studied is the arm chain (Table 3, Figure 1). One curious fact of this chain is that all authors, except for Souchard (inspiratory and hip chains), merge thorax and legs in the same chain [4,6-10,15]. On the other hand, all the five authors split the arm from the main chain, whereas Souchard [15] and Busquet [9] have two chains: arm anterior (AA) and shoulder anterior internal (SAI), and flexion (F) and extension (E), respectively; Myers has four: deep (DFA) and superficial front arm lines (SFA) and deep (DBA) and superficial back arm lines (SBA).

GDS [7] and Rosario [6,10] have three each. GDS uses the same name of the previous chains: anteromedian (AM), posteromedian (PM), and posterioranterior-anteroposterior (PA-AP). Rosario has the shoulder adductor (SA), arm internal rotator (AIR), and shoulder elevator-abductor (SEA).

	Mézières	GDS	Rosario	Busquet	Myers	Souchard
	Brachial (BC) and Posterior (PC) Chains	Anteromedian (AM), Posteromedian (PM) and Posteroanterior Anteroposterior (PA-AP) Chains	Shoulder Adductor (SA), Arm Internal Rotator (AIR) and Shoulder Elevator-Abductor (SEA) Chains	Flexion (F) and Extension (E) Chains	Deep front arm (DFA), Superficial Front Arm (SFA), Deep back arm (DBA) and Superficial back arm (SBA) line	Arm anterior (AA) and Shoulder Anterior Internal (SAI) chains
Anterior section of the deltoideus		AM		F	SBA	
Medial section of the deltoideus			SEA		SBA	AA
Posterior section of the deltoideus		PM		E	SBA	
Supraspinatus			SEA		DBA	
Teres minor		PM			DBA	
Infraspinatus		PM			DBA	
Subscapularis			SA - AIR		DBA	SAI
Levator scapulae			SEA		DBA	
Rhomboids					DBA	
Latissimus dorsi		PM			SFA	
Superior trapezius			SEA		SBA	AA
Inferior trapezius		PM			SBA	
Intermediate trapezius					SBA	
Pectoralis minor		PA-AP			DFA	
Pectoralis major			SA - AIR		SFA	SAI
Coracobrachialis		PA-AP	SA	F		AA
Biceps brachialis	BC	PA-AP	AIR	F	DFA	AA
Triceps brachii	PC	PM		E	DBA	
Brachialis	BC	AM	AIR	F		AA
Brachioradialis	BC		AIR			AA
Pronator teres	BC	PM	AIR			AA
Pronator quadratus	BC	PM	AIR			AA
Supinator		AM				
Abductors pollicis	PC	AM				
Finger extensors	PC	PA-AP				
Flexor carpi radialis	BC		AIR	F	SFA	AA
Flexor carpi ulnaris	BC		AIR	F	SFA	AA
Finger flexors	BC	PM	AIR	F	SFA	AA

Thenar muscles	BC		AIR		DFA	AA
Hypothenar muscles	BC		AIR		DBA	AA
Hand and finger extensors	PC			E	SBA	

Table 3: List of muscles of the arm chain. Mézières has the brachial (BC) and the posterior (PC), GDS has the anteromedian (AM), postero-median (PM), and the posterioranterior anteriorposterior (PA-AP); Rosario uses shoulder adductor (SA), arm internal rotator (AIR), and shoulder elevator-abductor (SEA); Busquet uses flexion (F) and extension (E); Myers uses deep (DFA) and superficial front arm lines (SFA), deep (DBA) and superficial back arm lines (SBA); and Souchard has the arm anterior (AA) and shoulder anterior internal (SAI) chains.

The lateral chain was the fourth to be analyzed (Table 4, Figure 2). At the level of the lower limbs, this chain has the tendency of abduction. It tends to unbalance the right and left sides of the body when shortening occurs in the spine region. A good example of this is scoliosis, which also involves the crossed chain. This chain is seldom compromised alone, being frequently coupled with any other chain. In fact, some of its muscles appear in other chains [4,7-9,11,12,15]. Interestingly, Souchard [13] described this chain only for the lower limb. Busquet [8,9] referred to a similar chain as static lateral chain. This, however, uses mainly connective tissue instead of muscles, which makes a comparison with the other chains difficult.

	Souchard	Myers
	Hip's lateral chain	Lateral Line
Sternocleidomastoid		X
Splenius capitis		X
Internal Intercostals		X
External Intercostals		X
Lateral abdominal obliques		X
Pyramidalis	X	
Abductor muscles		X
Tensor fasciae latae	X	X
Gluteus maximus	X	X
Peroneal muscles	X	X

Table 4: List of muscles in the lateral chain by Souchard and by Myers.

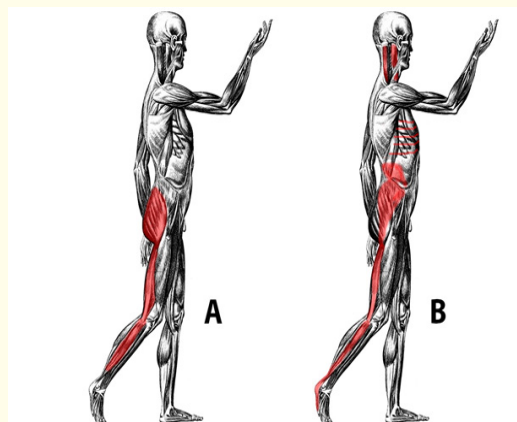


Figure 2: Visual comparison of the two lateral chains. A shows Souchard's hip lateral chain; B shows Myers's lateral line.

The last chain analyzed crosses the right and left sides of the body, promoting spiral movements (Table 5, Figure 3). Of all the chains studied in this article, this is the most controversial among the studied authors. This chain is clearly related to scoliosis and postures with a rotational component.

	GDS	Busquet	Myers	Piret-Beziars
	Posterolateral (PL) and Anterolateral (AL) Chains	Anterior Crossed (AC) and Posterior Crossed (PC) Chains	Spiral (SL), Front Functional (FF) and Back Functional (BF) Lines	Deep crossed layer – flexion (DCL) and Superficial crossed layer – extension (SCL)
Spenius capitis and cervicis			SL	SCL
Scalene				DCL
Erector spinae			SL	
Supraspinatus	PL			
Deltoides	AL - PL			
Lateral part of the triceps brachii	PL			
Anconeus	PL			
Extensor carpi ulnari	PL			
Flexor carpi ulnari	PL			
Abductor digiti minimi	PL			
Pars clavicularis of the SCM	AL			
Subscapularis	AL			
biceps brachii	AL			
supinator	AL			
Brachioradialis	AL			
Extensor carpi radialis longus and brevis	AL			
Palmaris longus	AL			
Thenar muscles	AL			
Lumbricales and interossei palmaris muscles	AL			
Flexor carpi radialis	AL			
Rhomboidei		AC	SL	
Intermediate trapezius	PL			
Inferior trapezius	PL	PC		
Pectoralis minor	AL	PC		
Pectoralis major		AC - PC	FF	
Teres major	AL	AC		
Transversus thoracis		PC		
Latissimus dorsi	AL	PC	BF	
Obliquus internus		AC	SL	DCL
Intercostales internus		AC		DCL
Obliquus externus		AC	SL	SCL
External intercostal		AC		SCL

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Serratus anterior			SL	
Superior posterior serratus		AC		SCL
Inferior posterior serratus		PC		SCL
Iliolumbar fibers of the erector spinae		PC		
Iliolumbar fibers of the quadratus lumborum		PC		
Iliocostal fibers of the quadratus lumborum		PC		
Internal intercostal muscles		PC		
Pectineus		AC		
Adductor longus			FF	
Adductor minimus		AC		
Adductor medius		AC		
Adductor maximus		AC		
Gluteus maximus		PC	BF	
Gluteus medius	PL - AL	PC		
Gluteus minimus		PC		
Piriformis		PC		
Gracilis		AC		
Semitendinosus		AC		
Biceps femoris	PL	PC	SL	
Vastus medialis		AC		
Vastus lateralis	PL	PC	BF	
Sartorius		PC		
Tensor fascia latae	AL	PC	SL	
Gastrocnemius lateralis	PL	AC		
Gastrocnemius medialis		PC		
Tibialis anterior	AL	PC	SL	
Tibialis posterior	AL	PC		
Peroneus Brevis	PL	AC		
Peroneus Longus	PL	AC	SL	
Peroneus Tertius	PL	AC		
Extensor hallucis longus		PC		
Flexor digitorum longus		PC		
Flexor hallucis longus		PC		
Plantaris	PL			
Interossei plantaris muscles	AL			
Lumbricalis muscles	AL			
Adductor hallucis		PC		
Abductor hallucis		AC		
Opponens digiti minimi		PC		

Table 5: List of muscles in the crossed chain. The GDS used the posterolateral (PL) and anterolateral (AL) chains; Busquet used the anterior crossed (closing) and posterior crossed (opening) chains; Myers used the spiral (SL), front functional (FF), and back functional (BF) lines; and Piret and Béziers used the deep crossed layer (DCL) and superficial crossed layer (SCL).

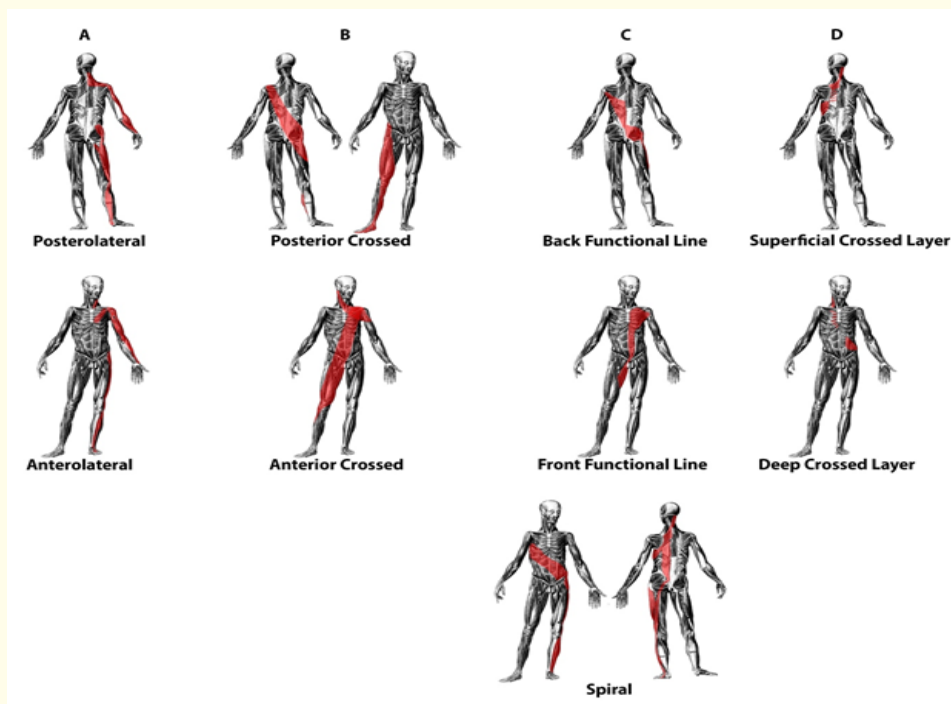


Figure 3: Visual comparison of all the crossed chains. A shows the GDS chains; B shows the Busquet chains; C represents Myers's lines; and D depicts Piret and Béziers's layers.

Discussion

Definitions of myofascial chains

Bones cannot move or stand against gravity by themselves. However, they give the solid basis for muscles to attach. Muscles, by pulling and pushing bones, provide the action required to generate movement or maintain bones in a balanced position, such as in the standing posture. Muscles generate force to produce movement or maintain body stability. The word force, in physics, refers to an interaction between at least two physical bodies [16]. Any kind of influence that causes an object to undergo a certain change in speed, direction, or shape is called force [16]. A force has both magnitude and direction, making it a vector quantity [16].

The connective tissue has a primordial role [17]. Bones are not the only connective tissue. The tendons that connect muscles to bones and the ligaments that stabilize bone segments are also part of this tissue. The fascia is another important part of the connective tissue that works together with muscles, involving the endomysium, epimysium and perimysium, helping them to contract and maintain tension [18,19]. Specifically, tension transmission across the epimysium contributes to muscle force [20,21]. That is why it makes sense to refer to myofascial structures or chains rather than muscle structures.

The human upright stance is an unstable position [22]. Bones are maintained upright through a very delicate balance [23]. Aided by the ligaments and fascia, muscles use their tonus and arch reflex to balance the body against gravity [24]. In general, muscles in the front part of the body generate influence towards a flexion [9]. Their force is balanced by the extension force of back muscles [9]. There are muscles that have force vectors acting in the same way laterally and rotationally [25]. They act in everybody segment at the same time [10]. A biomechanical reductionist example can be found in the standing position. The soleus and gastrocnemius muscles work together with the tibialis anterior muscle to maintain the ankle in an optimal position, while the hamstrings and quadriceps maintain the knees

and hips well positioned, and the back muscles and abdominals stabilize the torso, and the head with the flexor and extensor muscles keeping the eyes in a position that facilitates the gaze [25]. If a person flexes the head to look down, certain posterior muscles will need to compensate. The anterior muscles need to increase contraction while climbing a ladder, whereas the posterior muscles must contract more while descending the ladder [25].

At least one joint will be altered if there is an increase of muscle tonus or a shortening of a myofascial structure. This alteration may decrease the range of motion or fix the relaxed angle in a different position [26]. It can also rotate one segment in relation to the next [25] or generate a small slide at the joint surfaces, which is classified as a subluxation by chiropractors [27,28]. However, a muscle alteration usually affects more than one joint, especially if they are polyarticular [14]. These alterations are important to maintain balance, which can be defined as the ability to prevent falling (Pollock., *et al.* 2000). This chain reaction can begin anywhere, affecting any region, whether close or at a distance [25]. When a muscle changes one segment, other segments must change to a larger or smaller degree. Thus, they do not work alone, but rather in chains [10,14,25]. The theory of chains states that the region that receives the biggest impact of these changes is the region where the pain is located [10], which may be far from the initial altered segment. According to this theory, it is only possible to relieve postural pain by correcting the root alteration, as well as any other muscle or myofascial imbalance caused by it [10].

As a matter of fact, it is possible to consider that there is only one chain [10]. The body is all interconnected and works in synergy [29,30]. However, it is important to split the chains for didactic purposes. A chain-stretch exercise must put all structures of a chain in tension for a considerable amount of time, usually between 10 and 20 minutes, aiming to promote stretching, eccentrically if possible, while respecting joint physiology, such as the spinal curves, which must not be inverted during the exercise (Figure 4) [12]. Another characteristic is the correction of rotations and asymmetries during the exercise [10]. An eccentric stretch can relax a tensioned or hypertonic muscle, strengthen a weak muscle and stretch myofascial units [10]. Muscles tend to compensate when stretched [13]. In other words, when the hip is flexed to stretch hamstrings, there is a tendency for the knee to be in flexion. In a chain-stretch exercise, all compensations must be equally distributed along the chain [10]. These compensations must decrease while the degree of stretch tension must increase during the 20 minutes of exercise [10].

The term functional chain used in this article is related to a chain with a stronger effect on movement. The crossed chain is a good example. It can be involved in static problems such as scoliosis, but it is necessary for movements where girdle dissociation is required, such as walking and running [5]. On the other hand, a static chain obviously influences movement, but it is essential for postural maintenance [13].

Mézières Method, the origin and survival of the chains

Some experts believe that Mézières was a genius [14,31]. She grasped the idea of chains just by observing patients. She did it without the knowledge we have today in the field of postural control and the neurology of posture [32-34]. She developed a postural treatment with no clue about the strong fascial influence on muscle and posture [17,18,20]. Fascia can be so important to posture that recent studies suggest that fascia may be a contractile tissue [19,35,36]. She had no idea about the theories of muscle synergies [37-39], the effect of vision on posture [40,41] or the effect of malocclusion on posture [41-43]. She did not possess any evidence of the relationship between posture and emotions [44-46]. However, chain-based treatments seem to have effects on emotions [7,31,47].

Bertherat [31] described her teacher as a visionary in a world full of dogmas. Mézières had to break these dogmas to find a place for her new revolutionary ideas. In this process, she created her own dogmas, useful at the time. However, they are still blindly followed by some practitioners, thus preventing improvements in treatment procedures. Some, such as Carbonnel [48] and Nissand [14], believe that no one else should dare create different models of chains, calling them “impostors”. Specifically, Carbonnel cites two authors who should not have created their chains: Leopold Busquet, because he created more than 20 chains when Mézières created just four that satisfied her definition; and Tom Myers, because his lines are based on myofascial chains and fascial connection. It is interesting to note that none of this author’s affirmations are based on scientific evidence. Unfortunately, once such a discussion exists, it is important to evaluate Mézières rules based on modern science.

According to Carbonell [48] and Nissand [14], Mézières defined a muscular chain as “a group of polyarticular muscles running in the same direction and imbricated, i.e., overlapping like tiles on a roof, without any interruption of the linkage”. Thus, a very important question about the very basis of the method is: do only polyarticular muscles affect posture? Modern science answers this question as: No! A good example of this fact is the temporomandibular joint (TMJ). There are strong evidences that TMJ disorders alter posture [43,49,50]. Specially, the position of the cervical spine is easiest to alter because of its close relationship with the TMJ [51]. When the atlanto-occipital joint moves toward flexion, an associated sliding backward movement occurs in the same joint. When the movement is characterized by extension, it is associated with a sliding forward movement [52]. Forces generated by anterior translation of the atlas with the occipital (extension) lead to a retropulsion of the mandible. In the opposite case, cervical flexion provokes a translation and consequently a jaw antepulsion [53]. Among the most important muscles involved in the TMJ dysfunction are the masseter and pterigoid (lateral and medial). Although they are very important in the maintenance of the jaw position and can influence the entire body [25], they are not polyarticular muscles. Consequently, they are not part of any of Mézières chains.

Another example can be found with the patellofemoral pain syndrome, which is one of the most prevalent disorders involving the knee [54]. This is thought to have its roots from the tension and pressure of the mal-aligned patellofemoral joint [55]. Among the reasons for this malaligned joint are muscle tightness and abnormal limb rotations [56-58]. Despite the rotations, which can be caused by the posterior chain, the other cause of a patellofemoral malalignment is related to the muscle tension imbalance between vastus medialis and lateralis [57,58]. This is a serious postural problem caused by muscles not included in Mézières chains as well.

According to Carbonell [48] and Nissand [14] the first two Mézières law are: “1st - The numerous back muscles behave like a single muscle; 2nd - These muscles always end up too short and too toned.” It is also cited by Bertherat and Bernstein [31] as a Mézières quote: “the unique cause of its deformities: the shortening of the entire posterior musculature, which is the inevitable effect of the body’s daily movements” and “the problem is not in the posterior muscles insufficiency. It is not a matter of strengthening the back muscles, which are already to shortened.” These laws came from her clinical observation and are valuable. The problem is when these laws are treated as the only truth possible in any scenario. The various back muscles have a basic extension movement, common to the majority of them. However, they have different inclination and rotation functions. Thus, they do not always act as a single muscle. On the other hand, it is still possible to understand the clinical application of this massive extension torque. The second rule has an inherent problem with the words “always” or “unique cause”.

The back muscles are tonic; they must fight against gravity to maintain the standing posture. Thus, they are generally strong enough to do their job and it is easy to understand that under such conditions they can easily become stiff, thus complicating posture [59,60]. However, it is a tendency and not an infallible rule; the human body is full of possibilities and this statement can be quite reductionist. An example can be found in the bent spine syndrome, characterized, in the erect position, by a pronounced kyphosis and a limited trunk extension, also characterized by a progressive paraspinal muscle weakness [61].

Mézières’ third law is very controversial: “Any local work, whether of a shortening or lengthening nature, can only result in the shortening of the whole system (or chain)” [14,48]. Although there are some evidence that local work, such as stretching a shortened pectoralis major aiming to correct a protruded shoulder, does not work [62,63], it does not mean it will be harmful or will make the whole system shorter. Actually, there are also some evidence showing it can improve posture [64,65]. This statement affirms that postural faults are always caused by the whole chain and the muscles always work together. There would be no problem if the statement highlighted just a possibility of global evolvement, as it seems that sometimes this third law is true and sometimes it is not [63-65]. Another reason for the failure of some local strengthening/stretching exercises is the lack of biomechanical analysis of them [63], assuming, for example, that lumbar lordosis is only caused by a weakness of the abdominal muscles or short paravertebral muscles. Other local muscles, such as the diaphragm, might be involved [12,14].

A study comparing the chain stretching (15 minutes) with segmental stretch (using the same muscles of the chain, stretching each muscle for 30 seconds) had the same benefit for increasing hamstring length [26]. Using the same methodology, Rosario, *et al.* [12] ob-

served an improvement in posture with a chain stretch when compared with the static stretch. Putting these two studies together, it is possible to have two conclusions. Firstly, it is possible to save time and money using the static stretch to increase the hamstring length, which can be self-applied and needs to be held for only 30 seconds instead of 15 or 20 minutes. Secondly, if there is a superior improvement in the posture with the chain-stretch exercise, but both chain-stretch and segmental stretch are similar for muscle length, there is a good possibility that the postural improvement is achieved through a different mechanism other than muscle stretch. Therefore, Mézières' method of relying on a principle of correcting shortened muscles does not hold good.

Another law states "the limbs rotations due to shortening of the chains are always in internal rotation." This tends to be true in women, but not for men. The female pelvis is larger, broader, with a larger inlet, and is oval in shape, whereas the male pelvis is taller, narrower, with a further projected promontory, and is more compact. [66]. The iliac crests are higher and more pronounced in males [67]. The male sacrum is long, narrow, straighter, and has a pronounced sacral promontory when compared to females [67]. Thus, the sacrum and the pelvic ring of the female are wider and more circular, facilitating the passage of the newborn. This provokes the acetabula to be wider and face more anteriorly [67,68]. Consequently, a wider pelvis means a different angle with the femur, leading to a tendency of genu valgus and internal rotation of the femur. As a consequence, females have higher tendency of having a flat foot [25]. Bricot [25] also demonstrates that internal rotation is connected to the iliopsoas (anterior chain). The external rotation is related more to gluteus maximus and other types of posterior chain dysfunction, which is the opposite of Mézières' statement.

Another interesting quote can be found in the study by Bertherat and Bernstein [31] when they describe Mézières' gold standard for the perfect body form: "the only normal morphology is that which corresponds to the relation of the proportions of the body's parts to one another that characterizes Greek art of the classical period". It is poetical and it is possible to understand the clinical correlation of symmetry in which her method is based. However, for achieving the body of a Greek god, it is more important to have proper nutrition and a strong physical practice. Furthermore, it is difficult to find a Greek statue with prognatism, retrognatism, or a patellar tilt, two postural dysfunctions not covered by Mézières' chains, as discussed before.

According to her students [31] Mézières was a visionary and a genius. She broke the paradigms of her times. She created a very interesting form of therapy. However, contrary to the statement made by some authors such as Carbonell [48] and Nissand [14], it is clear that her method needs to be actualized, which some of her students have been doing. Carbonell [48] states that creation of new chains only "babelize the mapping of the body". This statement paraphrases the Holy Bible and Alfred Korzybski's [69] statement: "A map is not the territory." Mézières was among the first explorers to draw a chain map. However, the body will always be the body, it does not matter who is trying to map it. In the same way new drugs do not babelize the medicine, better maps must be produced with improved modern tools.

There is a quote created by Megginson [70], which has been frequently attributed to Sir Charles Darwin that reflects this moment: "According to Darwin's Origin of Species, it is not the most intellectual of the species that survives; it is not the strongest that survives; but the species that survives is the one that is able best to adapt and adjust to the changing environment in which it finds itself." Thus, in this new environment of modern science and many different manual therapy techniques, the fate of the Mézières method is to die if it does not adapt.

Which of the theories are more sustained by anatomy and biomechanics?

One thing in common with the chains created by Mézières' students is that all of them noticed the necessity of a more complete anterior chain [7-11,13]. Mézières also noticed this fact and included anterior muscles in her chains [14]. The anterior neck chain was not her creation and was included in her work only in 1984 [14]. The body is balanced between the muscles in opposite sides of the body: anterior and posterior muscles, muscles from both laterals of the body. This balance is extremely important not just at the biomechanical level [10], but even for the psychological dimension of the postural construction [44,71,72].

All of the reviewed models have the support of a deep biomechanical and anatomical study. In general lines, with exception of Mézières' chains that basically rely on a posterior chain, they use similar structures splitting the body in an anterior and a posterior part. On the

other hand, it is clear that they have some important differences that should be addressed in this review for a better comprehension of the muscular chains.

The biggest difference found is in the work of Busquet. Some details of his chains are clearly based in the work of Piret and Béziers [5]. These authors made a beautiful study of the human motor coordination, developing some patterns and chains of movement. However, they were much more concerned with the movement rather than posture. They gave some information about the spiral chains at the trunk level and described some patterns of muscle contraction in a specific phase of the gait for the lower limb and prehension movement for the upper limb. At the lower limb level, they studied the opposite movements of the gait: raising foot and knee, and impulse for the stride. When lifting the foot, they identified a chain of muscles composed of flexors: iliopsoas (hip flexor), hamstrings (flexor of the knee), and dorsiflexors. The description of the stride impulse movement involves the gluteus (hip extensor), the quadriceps (knee extensor), and the gastrocnemius and soleus (plantar flexors).

These are the same muscles used by Busquet [8] in his extension and flexion chains. The extension chain is almost totally posterior, changing to the quadriceps and back to the triceps sural. The flexion chain is anterior until the hip, going posterior with the hamstrings and back to the anterior with the extensor digitorum longus. The problem of this model is the difficulty of applying a chain-stretch exercise (Figure 4) as proposed by his teacher, Françoise Mézières. The philosophy of the chain-stretch exercise is to stretch all the muscles within a chain at the same time. It is difficult to manage a stretching tension at the iliopsoas and hamstrings together. The hamstring is a knee flexor and a hip extensor, whereas the iliopsoas is a hip flexor. The same thing happens with gluteus and quadriceps. They have opposite actions on the hips.

It is important to notice that Piret and Béziers [5] were not describing a posture but a movement. However, even in the movement of lifting the knee, it is not possible to forget the important action of the quadriceps flexing the hip.

GDS chains are somewhat complex to understand. She describes an anterior (anteromedian) and a posterior chain (posteromedian) [7]. The problem is the anteroposterior posteroanterior chain. It is not exactly a chain but a postural pattern. There are two main straight chains (anterior and posterior). However, different muscle shortenings in different parts of the chains may lead to several different postural patterns. Her method is interesting while linking the postural patterns to emotions [7]. However, confounding these patterns with muscular chains is inaccurate.

Souchard [15] and Rosario [6,10] have more compliance with the method developed by Mézières [1,14,73]. The main differences between them rely on some muscles and on the division of the chains. On the other hand, both authors have basically the anterior and the posterior chain. While most of the authors describe just the anterior part of the arm, Mézières [14] and Myers [4] describe the posterior part as well.

Myers [4] studied the anatomy of the myofascial tissue. To be considered a “line,” the myofascial structures involved had to follow some rules, such as showing continuity of fascial fibers and having the same direction and same depth. Despite the completely different approach, his lines are very similar to the majority of the chains reviewed. The clear anatomical rules this author followed make his model the best reliable one among the six.

In the case of the lateral chain it is easy to define, once there are just two authors and one of them [13] describes just a fraction of it. In addition, the leg muscles are very well matched between the two authors.

For the crossed chain, it is a whole different scenario. The GDS explains emotions through postures. Denys-Struyf [7] stated that Anterolateral (AL) and Posterolateral (PL) postures are related to internal rotation (an introverted personality) and external rotation (an extroverted personality). These chains do not really fit into any other category because they are not straight. Thus, they cannot be listed with the anterior, posterior, or lateral chain and are best compared with the crossed chain. On the other hand, both AL and PL postures do not deal with trunk rotations, which is the basis of the other chains. This may be the reason why the AL almost did not match any other

author's chains. The PL chain is slightly similar to Busquet's posterior crossed chain. However, their similarities are so few that they may only be coincidental.

Both Busquet [8,9] and the GDS [7] do not include neck muscles in their chains, as opposed to Myers [4] and Piret and Béziers [5]. When comparing the chains proposed by Busquet (2001, 2002) with those put forward by Piret and Béziers [5], it is possible to find almost the same muscles. The main difference is that Piret and Béziers [5] wrote only about the muscles of the trunk as a chain, describing just eight muscles, while Busquet [8,9] described many muscles and not only those in the trunk. It is worth noting that the majority of the muscles proposed by Piret and Béziers [5] relate to the anterior crossed chain [8,9], regardless of whether it is a flexion chain (deep crossed layer) or an extension (superficial crossed layer). One line proposed by Myers [4] correlates with one of Busquet's chains. The back functional line muscles are included in the description of the posterior crossed chain, unlike the spiral line and the back functional line muscles.

These differences may be due to the fact that crossed chains are much more dynamic than static [5]. To stand or sit, it is necessary to contract the muscles of the straight anterior and posterior chains-maybe even the lateral chain. However, the crossed chains are extremely important to gait, dissociating the scapular and pelvic girdles [5]. This is more evident in a running movement. While there are many ways that a person can stand, these ways are few compared to the number of ways a person can make a movement, such as bringing a glass of water toward the mouth. This is probably the reason why the descriptions of the crossed chains differ from one author to another.

For the same reason that it was chosen as a better-sustained theory for the straight chains, Myers [4] can also be chosen as the better-sustained theory for the crossed chains. Again, the clear anatomical rules this author followed, with a stronger anatomical base than Mézières or their students, make his model the most reliable among those reviewed.

What would be the best model for chain-stretch postural exercises?

Despite the fact all the proposed chains have an anatomical basis, the work of Myers is the most deeply based on anatomy and structure. However, a pure myofascial approach may lack efficacy for a chain-stretch based treatment for some reasons.

Fascia is essential for the postures and the patterns of human movements [18]. This special tissue plays an important role in musculo-skeletal dynamics, namely stability, lengthening of tissues, strength transmission, among other roles [20,21,74]. It seems that fascia reorganizes along the lines of biomechanical tension at molecular [75,76] and macroscopic level [77]. The repercussion of a fascial restriction could probably create stress in the entire body, on any structures enveloped by fascia [78]. Myers [4] found a continuous anatomical relationship along the tensile myofascial bands comprising a single continuous structure, similar to other chains described in this review. Thus, the myofascial lines outlined by Myers [4] works as a path. Similar to its geographical counterpart that is created with the purpose of facilitating transit, this fascial path facilitates the stabilization, strength production, and length control of the most commonly used muscle synergies and patterns [79,80]. These synergies would be the most common for both postural maintenance and to serve as basis to many different types of movement [81-83].

That fact may explain why a posterior chain has a fascial support. To stand is a very important position, frequently adopted. The gait is an essential movement, which has a crossed chain with a fascial structure to support this muscular path frequently used. Nevertheless, it is obvious that the human body is capable of innumerable combinations of muscle contractions, facilitating many different movements. An unusual movement would "borrow" muscles from outside the path. This may also happen in posture. An alteration of the equilibrium of the unstable human upright stance [22], moving the center of gravity outside the base of support provided by the feet, may require the body to recruit muscles usually not recruited for postural maintenance. In this case, the body needs the contraction of muscles out of the path. The problem is that these muscles are used to perform short dynamic movements. When they need a constant contraction to compensate a postural fault and allow the body to stand, they may provoke pain. That is one reason some muscles not connected through the fascial web should integrate into a chain used for chain-stretch exercises.

Another reason relies on the fact that chain-stretch exercises sometimes put the body in an extreme position (Figure 4) not usually adopted in common postures of the daily life, such as seating or standing. Thus, because different muscles are activated along with the chain muscles, they should be considered. All muscles with the same action of the muscles included in the chain might be contracted in these exercises.

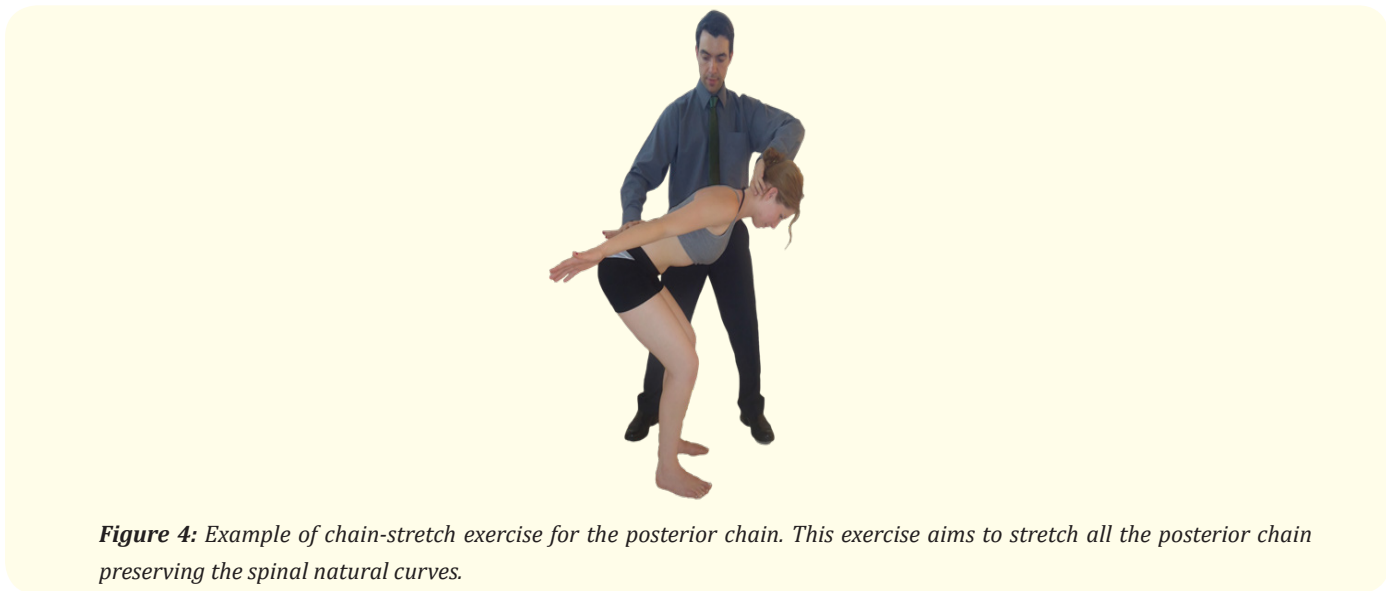


Figure 4: Example of chain-stretch exercise for the posterior chain. This exercise aims to stretch all the posterior chain preserving the spinal natural curves.

Another reason can be found in the pathogenesis of the myofascial trigger points (TP). According to Rickards [84], TP can arise in any muscle group. However, in accordance with the one of the most important authors in the field and former Personal Physician of the iconic U.S. President John F. Kennedy, the most common sites for a TP are the muscles involved in maintaining posture, specially levator scapulae, upper trapezius, sternocleidomastoid, scalenes, and quadratus lumborum muscles [85,86]. Alvarez and Rockwell [87] highlight that muscles more susceptible to develop TP include the ones used to maintain body posture, such as those in the neck, shoulders, and pelvic girdle. Travell and Simons [85] suggest that poor posture is among the factors involved on the histopathologic mechanism of the TPs. Many other authors agree that posture is a main causative factor for TPs [88-90]. Fernández-de-Las-Peñas, *et al.* [91] found links between migraine, forward head posture, and presence of TP in the upper trapezius, sternocleidomastoid, temporalis, and suboccipital muscles. For Baldry [92], the correction of any postural disorder likely to cause TP is essential. Edwards [93] relates clinical experiences where a number of postural habits, adopted during the course of sitting, standing, or sleeping, were responsible for the TP. According to this author, correcting the postural faults is a necessary contribution to treatment, as failure to do so could lead to persistence of the pain.

It is important to notice that two muscles commonly affected with TP listed by Travell and Simons [85] are not listed in any of the chains or in a very few of them. Suboccipital muscles can be divided into rectus capitis posterior major and minor and obliquus capitis superior and inferior. Both recti capitis are in Rosario’s and Mézières’ posterior chain. Both obliquus superior and inferior appear just in Mézières’ list. Similarly, the quadratus lumborum appears only in Godelieve Denys Struyf (GDS’s) posterior-anterior-anterior-posterior (PA-AP) chain and in Busquet’s posterior crossed chain.

Increased tension maintained for long periods in a bad position may be the cause of this pain [92]. As seen in the examples above, the muscles affected by the postural tension can be outside the myofascial track, “borrowed” to maintain the equilibrium. This “borrowing” obviously happens because the affected muscle can perform the action needed to maintain balance.

Because of these reasons, some structures, based on muscle action, should be added to improve, for example, in the case of a postural treatment that involves chain stretching, chain strengthening, or even chain coordination [12].

Thus, to bring together the best of two worlds, the following considerations must be made before proposing a new model to use for chain-stretch exercises:

- A. Because of the chain-stretch exercises, all muscles of the chain should be stretched at once. If two chains can be stretched at the same time, they should be merged. If they cannot, they should be kept separated.
- B. A muscle that has the same action of another that is included in one chain must be included in it.
- C. One muscle can be present in more than one chain.
- D. Muscles related to a part of the body that has an important implication to the posture but is not included in any chain must be included in some way. A good example of this is the muscles of the temporomandibular joint (TMJ), which have an important influence in posture [49]. However, four of the six authors have not included them in their chains.

Posterior Chain (Figure 5)

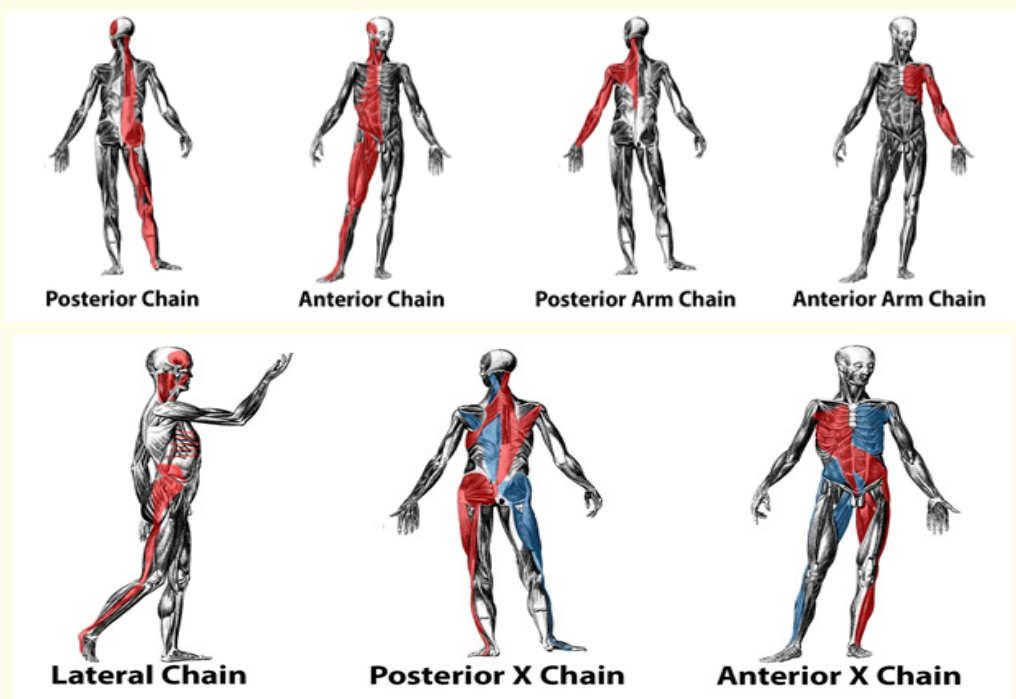


Figure 5: Illustration of the proposed myofascial chains. The first row contains the straight chains (Posterior, Anterior, Posterior Arm, Anterior Arm). Second row contains the straight lateral chain and the crossed chains (Posterior X and Anterior X).

Myers’ superficial back line has the following muscles: erector spinae muscles, hamstrings, gastrocnemius, and short toe flexors.

According to principle B (same muscle functions), these muscular groups should be included: all spine extensors from the head to the sacrum, all hip extensors, all knee flexors, all plantar flexors, and all toe flexors.

The connective tissue elements related to this chain are the galea aponeurotica/epicranial fascia, sacrolumbar fascia, sacrotuberous ligament, Achilles tendon, and plantar fascia [4].

The TMJ is a very influential factor for the neck posture. Consequently, through the neck, it may alter the whole body [49]. Principle D suggests the inclusion of the related muscles: temporalis, masseter, and pterygoids.

Anterior Chain (Figure 5)

According to principle A, the superficial front line and the deep front line should be merged: suprahyoid muscles, infrahyoid muscles, longus colli and capitis, transversus thoracis, scalene muscles, sternocleidomastoid, sternalis, diaphragm, rectus abdominis, femoral triangle, pectineus, iliacus, psoas, levator ani, adductor brevis, adductor magnus and minimus, rectus femoris/quadriceps, short and long toe extensors, tibialis anterior, and—special attention should be given to the next muscles: tibialis posterior and long toe flexors.

In accordance to principle B, the following muscles and muscular group should be added in a functional version: all flexors of the spine from head to pelvis, all muscles involved in inspiration, adductors of the hip, pelvic floor muscles, flexors of the hip, all extensors of the knee, all dorsiflexors, and all toe extensors. Because of this connection with the tibialis posterior and the long toe flexors, the plantar flexors and toe flexors should be added (principle C), which may require some slight alterations in the stretch position in case of a shortening in this part of the chain. The inversion of the foot will be seen in the spiral chain at the second part of this article.

The connective tissues elements added by Myers [4] in these two chains are as follows: scalp fascia, fascia pretrachialis, medial scalene fascia, pharyngeal raphe, sternochondral fascia, fascia endothoracica, fascia prevertebralis, pericardium, mediastinum, parietal pleura, crura and central tendon of the diaphragm, anterior longitudinal ligament, anterior intermuscular septum, anterior longitudinal ligament, pelvic floor fascia, posterior intermuscular septum, fascia of the popliteus, and subpatellar tendon and anterior crural compartment.

Arm Chains (Figure 5)

Anterior arm chain

This is the fusion of the deep front arm line and superficial front arm line: pectoralis minor; pectoralis major; latissimus dorsi; biceps brachii; flexor group; and thenar muscles. For the function, the following should be added: all shoulder adductors and internal rotators, all muscles responsible for abduction of the scapula and scapula alata (winged), and elbow flexors. Two important muscles to add are pronator teres and quadratus because pronation is related to many tasks.

The connective tissues elements added by Myers [4] in these two chains are as follows: clavipectoral fascia, anterior border of the radial periosteum, medial intermuscular septum, radial collateral ligaments, and carpal tunnel.

Posterior arm chain

This is the fusion of the deep back arm line and superficial back arm line: trapezius; deltoid; rhomboids; levator scapulae; rotator cuff muscles; triceps brachii; extensor group; and hypothenar muscles.

Connective tissue elements [4] are as follows: ulnar periosteum, ulnar collateral ligaments, and lateral intermuscular septum.

Lateral Chain (Figure 5)

Myers's lateral line includes the following muscles: the sternocleidomastoid, splenius capitis, external and internal intercostals, lateral abdominal obliques, tensor fasciae latae, gluteus maximus, abductor muscles, and peroneal muscles.

According to principle B (same muscle functions), muscles that can laterally incline the head and the spine should be included. Two very important muscles in this group are the scalenes and the quadratus lumborum.

Lateral deviations at the TMJ or a crossed bite can produce an inclination in the neck posture. Consequently, through the neck it may affect the whole body [49]. Principle D suggests the inclusion of related muscles: the pterygoids. These muscles are also present in the straight posterior chain, which is in accordance with principle C.

The connective tissue elements related to this chain are the tractus iliotibialis, the anterior ligament of the head of the fibula, and the lateral crural compartment [4].

Crossed Chain (Figure 5)

The crossed chains are a very special case. Because they are dynamic rather than static, their functionality differs from that of the other straight chains. As previously discussed, there are innumerable different movements that the human body can perform. However, it seems there are only a few myofascial paths commonly used for typical patterns of human movements [4]. Having a path would make the movements easier and less energy-consuming. The spiral line binds itself to the posterior chain through the splenius, erector spinae, and biceps femoris, and to the lateral chain through the tensor fasciae latae and peroneus longus. The front functional line is connected to the anterior chain through the pectoralis, rectus abdominis, and adductor longus. The crossed chains and their fascias are like tape around the body, with the straight chains as the foundation for movement generation.

The parts of the body are all connected. This chain is not an exception. However, to better understand the connections and to create a model that is easy to apply to functional situations, it is necessary to split the body into front and back. Thus, one part of the spiral line is joined to the back functional line, according to rule A, and the other part is connected to the front functional line.

Posterior X chain

The back part of the spiral line and the back functional line together include the following muscles: the erector spinae, latissimus dorsi, gluteus maximus, biceps femoris, vastus lateralis, tensor fasciae latae, iliotibial tract, tibialis anterior, and peroneus longus.

According to principle B (same muscle functions), these muscular groups should be included: shoulder external rotators, hip external rotators, and abductors. The connective tissues elements added by Myers [4] to these two chains are the sacrotuberous ligament, sacrolumbar fascia, and subpatellar tendon.

Anterior X chain

The front part of the spiral line and the front functional line together include the following muscles: the splenius capitis and cervicis, Rhomboids major and minor, serratus anterior, pectoralis major, lateral sheath of the rectus abdominis, external and internal obliques, and adductor longus.

According to principle B (same muscle functions), these muscular groups should be included: shoulder internal rotators, hip internal rotators, and adductors.

The connective tissues elements added by Myers [4] to these two chains are the abdominal aponeurosis and linea alba.

Final Considerations

The structures selected cover, in a logical manner, the majority of muscles of all the chains reviewed and can serve as the basis for future postural treatments that work with the stretching of muscle or myofascial chains.

A possible critic for this model is the lack of differentiation between muscles with a predominance of fiber types I (slow twitch) and II (fast twitch). The type I fibers, because of their better use of oxygen, are related to postural activities that must be sustained for a long time [6,10]. However, the connective tissue must be taken into consideration. Fascial structures can be shortened around any type of muscle. Besides, when the target of the chain stretching is the function, the shortened muscle or the fascia will be the most affected by the treatment [94].

The logic of the lateral chain follows that of the other straight chains. However, the crossed chain has a strong dynamic component; it can be altered depending on the type of movement to be analyzed or treated. It is interesting to note some similarities that the crossed chains have with some proprioceptive neuromuscular facilitation (PNF) patterns.

For example, the upper part of the anterior X chain plus the anterior arm chain have many muscles in common with the arm PNF pattern of extension–adduction–internal rotation. The anterior X chain and the posterior arm chain together are correlated to the pattern of

flexion–adduction–external rotation. The posterior X chain and the posterior arm chain together are coupled with the pattern of flexion–abduction–external rotation. The posterior X chain plus anterior arm chains are related to the pattern of extension–abduction–internal rotation [6].

The same correlation to PNF lower limb patterns occurs when only the lower limb components of the straight anterior and posterior chains are used with the crossed chains [6]. Similarly, to PNF, when considering the correction of different movements, it is possible to add different joint motions, such as knee or elbow flexion, to alter the muscles involved.

It is important to remember that despite the fact the muscular chains seem to be a very efficient method of diagnosing and treating postural problems [12], its results are predominantly empirical because of the few scientific studies in the area. Therefore, scientifically speaking, it is not possible to affirm the existence of the chains. Electromyographic studies seem to be an efficient way to understand and verify the existence and behavior of the chains and the exact muscular structures involved in them. Another important task for scientists is to discover which chain model is the most suitable and which exercise is the most efficient for treatment. Right now, it is only possible to speculate based on the theoretical construct provided by each author. Since scientists require standardization to reduce bias, the model presented herein is offered for scientific, teaching and treatment purposes. Free use is encouraged with the proper citation [95,96].

Conclusion

Of the six authors reviewed, the approach made by Myers is the most reliable. It is advisable to use his model for the application of myofascial maneuvers aiming to improve the posture. For the same reasons provided, the approach by Myers is deemed the most trustworthy among the crossed chains. However, for a chain-stretching work or a dynamic activity, a different approach is necessary. This approach can be made based on Myers' lines and also has correlations with the other methods reviewed in the present study.

Conflict of Interest

There is no conflict of interest.

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Bibliography

1. Denys-Struyf G. "El manual del Mezierista. Tomo I". *Barcelona: Paidotribo* (2000a).
2. Mézières F. "Méthodes orthopédiques et kiésithérapiques et fonctions du sympathique". *Les Cahiers de la Méthode naturelle* 52 (1973).
3. Rolf IP. "Ida Rolf talks about rolfing and physical reality". *New York: Harper and Row* (1978).
4. Myers TW. "Anatomy Trains: Myofascial Meridians for Manual and Movement Therapists". *Philadelphia, PA: Churchill Livingstone* (2009).
5. Piret S and Bézières M-M. "A coordenação motora: aspecto mecânico da organização psicomotora do homem". *São Paulo: Summus* (1992).
6. Rosario JL. "Manual prático de facilitação neuromuscular proprioceptiva". *Baraúna: São Paulo* (2011a).
7. Denys-Struyf G. "Cadeias musculares e articulares". *O método G.D.S. São Paulo: Summus* (1995).

8. Busquet L. "Las cadenas musculares tomo IV: miembros inferiores". *Barcelona: Paidotribo* (2001).
9. Busquet L. "Las cadenas musculares tomo I: tronco, columna cervical y miembros superiores". *Barcelona: Paidotribo* (2002).
10. Rosario JL. "Manual prático de reeducação postural: o que você precisa saber para um tratamento eficiente". *São Paulo: Baraúna* (2011b).
11. Rosario JL. "Efficiency of modified yoga positions to treat postural pathologies associated pain: a literature review". *Journal of Yoga and Physical Therapy* 2 (2012): 128.
12. Rosario JL, et al. "Improving posture: Comparing Segmental Stretch and Muscular Chains Therapy". *Clinical Chiropractic* 15 (2012): 121-128.
13. Souchard PE. "Fundamentos da reeducação postural global: princípios e originalidade". *São Paulo: É Realizações* (2003).
14. Nissand M. "Método Mézières". *Kinesiterapia - Medicina física* (2010): 1-16.
15. Marques AP. "Cadeias musculares - um programa para ensinar avaliação fisioterapêutica global". *Manole, São Paulo* (2000).
16. Serway RA and Jewett JW. "Physics for Scientists and Engineers with Modern Physics. 9th Edition". - Brooks/Cole (2013).
17. Tozzi P, et al. "Fascial release effects on patients with non-specific cervical or lumbar pain". *Journal of Bodywork and Movement Therapies* 15.4 (2011): 405-416.
18. Schleip R. "Fascial plasticity-a new neurobiological explanation: part 1". *Journal of Body Bodywork and Movement Therapies* 7 (2003): 11-19.
19. Schleip R, et al. "Active fascial contractility: Fascia may be able to contract in a smooth muscle-like manner and thereby influence musculoskeletal dynamics". *Medical Hypotheses* 65.2 (2005): 273-277.
20. Garfin SR, et al. "Role of fascia in maintenance of muscle tension and pressure". *Journal of Applied Physiology* 51.2 (1981): 317-320.
21. Huijing PA. "Muscle as collagen fiber reinforced composite material: force transmission in muscle and whole limbs". In: Fukunaga T, Fukashiro S, editors. *Proceedings of the XVIth congress of the international society of biomechanics*. Tokyo University (1997): S7.
22. Peterka R and Loughlin P. "Dynamic regulation of sensorimotor integration in human postural control". *Journal of Neurophysiology* 91.1 (2004): 410-423.
23. Rosario JL. "Biomechanical analysis of human posture: a literature review". *Journal of Bodywork and Movement Therapies* 18.3 (2014): 368-373.
24. Cheung JTK, et al. "Effects of plantar fascia stiffness on the biomechanical responses of the ankle-foot complex". *Clinical Biomechanics* 19.8 (2004): 839-846.
25. Bricot B. "Total Postural Reprogramming". *Santa Monica: Dux Lucis Books* (2008).
26. Rosario JL, et al. "Reeducação postural global e alongamento estático segmentar na melhora da flexibilidade, força muscular e amplitude de movimento: um estudo comparativo". *Fisioterapia e Pesquisa* 15.1 (2008): 12-18.

27. Harrison D., *et al.* "Chiropractic biophysics technique: a linear algebra approach to posture in chiropractic". *Journal of Manipulative and Physiological Therapeutics* 19.8 (1996): 525-535.
28. Troyanovich SJ., *et al.* "Structural rehabilitation of the spine and posture: rationale for treatment beyond the resolution of symptoms". *Journal of Manipulative and Physiological Therapeutics* 21.1 (1998): 37-50.
29. Krishnamoorthy V., *et al.* "Muscle synergies during shifts of the center of pressure by standing persons: identification of muscle modes". *Biological Cybernetics* 89.2 (2003): 152-161.
30. Krishnamoorthy V., *et al.* "The use of flexible arm muscle synergies to perform an isometric stabilization task". *Clinical Neurophysiology* 118.3 (2007): 525-537.
31. Bertherat T and Bernstein C. "The body has its reasons: anti-exercises and self-awareness" (1977).
32. Spink MJ., *et al.* "Foot and ankle strength, range of motion, posture, and deformity are associated with balance and functional ability in older adults". *Archives of Physical Medicine and Rehabilitation* 92.1 (2011): 68-75.
33. Kang JH., *et al.* "The effect of the forward head posture on postural balance in long time computer based worker". *Annals of Rehabilitation Medicine* 36.1 (2012): 98-104.
34. Boyas S., *et al.* "Changes in posture associated with postural control impairment induced by ankle plantarflexor fatigue during unipedal quiet standing". *Neuroscience Letters* 547 (2013): 48-52.
35. Spector M. "Musculoskeletal connective tissue cells with muscle: expression of muscle actin in and contraction of fibroblasts, chondrocytes, and osteoblasts". *Wound Repair Regen* 9.1 (2002): 11-18.
36. Schleip R., *et al.* "Passive muscle stiffness may be influenced by active contractility of intramuscular connective tissue". *Medical Hypotheses* 66.1 (2006): 66-71.
37. Ting LH and Macpherson JM. "A limited set of muscle synergies for force control during a postural task". *Journal of Neurophysiology* 93.1 (2005): 609-613.
38. Ting LH. "Dimensional reduction in sensorimotor systems: a framework for understanding muscle coordination of posture". *Progress in Brain Research* 165 (2007): 301-325.
39. Ting LH and McKay JL. "Neuromechanics of muscle synergies for posture and movement". *Current Opinion in Neurobiology* 17.6 (2007): 622-628.
40. Mohapatra S., *et al.* "The effect of decreased visual acuity on control of posture". *Clinical Neurophysiology* 123.1 (2012): 173-182.
41. Silvestrini-Biavati A., *et al.* "Clinical association between teeth malocclusions, wrong posture and ocular convergence disorders: an epidemiological investigation on primary school children". *BMC Pediatrics* 13 (2013): 12.
42. Luzi V., *et al.* "Inter- relationships between orthodontics and posture: basic theories". *Annali Di Stomatologia (Roma)* 2.3-4 (2011): 45-48.
43. Manfredini D., *et al.* "Dental occlusion, body posture and temporomandibular disorders: where we are now and where we are heading for". *Journal of Oral Rehabilitation* 39.6 (2012): 463-471.

44. Wallbott HG. "Bodily expression of emotion". *European Journal of Social Psychology* 28 (1998): 879-896.
45. Carney DR, et al. "Power posing: brief nonverbal displays affect neuroendocrine levels and risk tolerance". *Psychological Science* 21.10 (2010): 1363-1368.
46. Rosario JL, et al. "Can sadness alter posture?" *Journal of Bodywork and Movement Therapies* 17.3 (2013): 328-331.
47. Hade-Hetú L. "Rendez-vous avec Thérèse Bertherat". *Santé mentale au Québec* 31 (1978): 97-100.
48. Carbonnel J. "The Weakest Chains". *Positive Health* 81 (2002).
49. Amat P. "Occlusion, orthodontics and posture: are there evidences? The example of scoliosis". *Journal of Stomatology and Occlusion Medicine* 2.1 (2009): 2-10.
50. Cuccia A and Caradonna C. "The relationship between the stomatognathic system and body posture". *Clinics (Sao Paulo)* 64.1 (2009): 61-66.
51. Huggare JA and Raustia AM. "Head posture and cervicovertebral and craniofacial morphology in patients with craniomandibular dysfunction". *Journal of Craniomandibular and Sleep Practice* 10.3 (1992): 173-179.
52. Kapandj AI. "Fisiología articular". Tronco y raquis. Madrid: Editorial médica panamericana (1999).
53. Makofsky HW. "The effect of head posture on muscle contact position: the sliding cranium theory". *Journal of Craniomandibular and Sleep Practice* 7.4 (1989): 286-292.
54. Witvrouw E, et al. "Clinical clas- sification of patellofemoral pain syndrome: guidelines for non- operative treatment". *Knee Surgery, Sports Traumatology, Arthroscopy* 13.2 (2005): 122-130.
55. Sanchis-Alfonso V, et al. "Pathogenesis of anterior knee pain syndrome and functional patellofemoral instability in the active young: a review". *American Journal of Knee Surgery* 12.1 (1999): 29-40.
56. Merchant AC, et al. "Roentgenographic analysis of patellofemoral congruence". *Journal of Bone and Joint Surgery - American* 56.7 (1974): 1391-1396.
57. Grelsamer RP. "Patellar malalignment". *Journal of Bone and Joint Surgery - American* 82-A11 (2000): 1639-1650.
58. Fulkerson JP. "Diagnosis and treatment of patients with patellofemoral pain". *American Journal of Sports Medicine* 30.3 (2002): 447-456.
59. Hamaoui A, et al. "Does postural chain muscular stiffness reduce postural steadiness in a sitting posture?" *Gait Posture* 25.2 (2007): 199-204.
60. Hamaoui A, et al. "Does increased muscular tension along the torso impair postural equilibrium in a standing posture?" *Gait Posture* 34.4 (2011): 457-461.
61. Serratrice G, et al. "Bent spine syndrome". *Journal of Neurology, Neurosurgery, and Psychiatry* 60.1 (1996): 51-54.
62. Hrysonallis C and Goodman C. "A review of resistance exercise and posture realignment". *Journal of Strength and Conditioning Research* 15.3 (2001): 385-390.

63. Hrysomallis C. "Effectiveness of strengthening and stretching exercises for the postural correction of abducted scapulae: a review". *Journal of Strength and Conditioning Research* 24.2 (2010): 567-574.
64. Muyor JM., *et al.* "Effect of stretching program in an industrial workplace on hamstring flexibility and sagittal spinal posture of adult women workers: a randomized controlled trial". *Journal of Back and Musculoskeletal Rehabilitation* 25.3 (2012): 161-169.
65. Yoo WG. "Effect of thoracic stretching, thoracic extension exercise and exercises for cervical and scapular posture on thoracic kyphosis angle and upper thoracic pain". *Journal of Physical Therapy Science* 25.11 (2013): 1509-1510.
66. Schuenke M., *et al.* "Thieme Atlas of Anatomy. General Anatomy and Musculoskeletal System". *Stuttgart: Thieme* (2006).
67. Merry Clare V. "Pelvic Shape". *Mind - Primary Cause of Human Evolution*. Trafford Publishing (2005).
68. Nakahara I., *et al.* "Gender differences in 3D morphology and bony impingement of human hips". *Journal of Orthopaedic Research* 29.3 (2011): 333-339.
69. Korzybski A. "Science and Sanity: an introduction to Non-Aristotelian Systems and General Semantics". Institute of General Semantics, New York (1933).
70. Megginson LC. "Lessons from Europe for American Business". *Southwestern Social Science Quarterly* 44.1 (1963): 3-13.
71. Keleman S. "Embodying Experience: Forming a Personal Life". Berkeley: Center Press (1987).
72. Rosario JL., *et al.* "How can depression alter posture?" *Journal of Bodywork and Movement Therapies* (2014).
73. Denys-Struyf G. "El manual del Mezierista. Tomo II". *Barcelona: Paidotribo* (2000b).
74. Barker P., *et al.* "Tensile transmission across the lumbar fasciae in unembalmed cadavers: effects of tension to various muscular attachments". *Spine* 29.2 (2004): 129-138.
75. Dunn MG and Silver FH. "Viscoelastic behavior of human connective tissue: relative contribution of viscous and elastic components". *Connective Tissue Research* 12.1 (1983): 59-70.
76. Mosler E., *et al.* "Stress-induced molecular arrangement in tendon collagen". *Journal of Molecular Biology* 182.4 (1985): 589-596.
77. Sasaki N and Odajima S. "Elongation mechanism of collagen fibrils and force-strain relations of tendon at each level of structural hierarchy". *Journal of Biomechanics* 29.9 (1996): 1131-1136.
78. Greenman P. "Principles of Manual Medicine". *Williams and Wilkins, Baltimore, MD* (1989).
79. Massion J. "Postural control systems in developmental perspective". *Neuroscience and Biobehavioral Reviews* 22.4 (1998): 465-472.
80. Chvatal SA and Ting LH. "Common muscle synergies for balance and walking". *Frontiers in Computational Neuroscience* 27 (2013): 48.
81. Tresch MC., *et al.* "The construction of movement by the spinal cord". *Nature Neuroscience* 2.2 (1999): 162-167.
82. Torres-Oviedo G and Ting LH. "Muscle synergies characterizing human postural responses". *Journal of Neurophysiology* 98.4 (2007): 2144-2156.

83. d'Avella A., *et al.* "Control of fast-reaching movements by muscle synergy combinations". *Journal of Neuroscience* 26.30 (2006): 7791-7810.
84. Rickards LD. "The effectiveness of non-invasive treatments for active myofascial trigger point pain: A systematic review of the literature". *International Journal of Osteopathic Medicine* 9.4 (2006): 120-136.
85. Travell JG and Simons DG. "Myofascial pain and dysfunction: the trigger point manual: the upper extremities". Baltimore: Williams and Wilkins 1 (1983).
86. Simons DG. "Review of enigmatic MTrPs as a common cause of enigmatic musculoskeletal pain and dysfunction". *Journal of Electromyography and Kinesiology* 14.1 (2004): 95-107.
87. Alvarez DJ and Rockwell PG. "Trigger points: diagnosis and management". *American Family Physician* 65.4 (2002): 653-60.
88. Han SC and Harrison P. "Myofascial pain syndrome and trigger-point management". *Regional Anesthesia* 22.1 (1997): 89-101.
89. Wheeler AH. "Myofascial pain disorders: theory to therapy". *Drugs* 64.1 (2004): 45-62.
90. Hoyle JA., *et al.* "Effects of postural and visual stressors on myofascial trigger point development and motor unit rotation during computer work". *Journal of Electromyography and Kinesiology* 21.1 (2011): 41-48.
91. Fernández-de-Las-Peñas C., *et al.* "Myofascial trigger points, neck mobility and forward head posture in unilateral migraine". *Cephalalgia* 26.9 (2006): 1061-1070.
92. Baldry P. "Management of myofascial trigger point pain". *Acupuncture in Medicine* 20.1 (2002): 2-10.
93. Edwards J. "The importance of postural habits in perpetuating myofascial trigger point pain". *Acupuncture in Medicine* 23.2 (2005): 77-82.
94. Alter M. "The science of flexibility". Champaign, IL: Human Kinetics (2004).
95. Pitterman H and Nowicki S Jr. "A test of the ability to identify emotion in human standing and sitting postures: the diagnostic analysis of nonverbal accuracy-2 posture test (DANVA2-POS)". *Genetic Social and General Psychology Monographs* 130.2 (2004): 146-162.
96. Shahidi B., *et al.* "Differential effects of mental concentration and acute psychosocial stress on cervical muscle activity and posture". *Journal of Electromyography and Kinesiology* 23.5 (2013): 1082-1089.

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