Journal of Bodywork & Movement Therapies (2015) 19, 304–309

Available online at www.sciencedirect.com

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journal homepage: www.elsevier.com/jbmt

FASCIA SCIENCE AND CLINICAL APPLICATIONS: RESPONSE

Van Der Wal's response to Stecco's fascial nomenclature editorial
Some functional considerations as to nomenclature in the domain of the fascia and connective tissue

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Received 14 January 2015; accepted 14 January 2015

Nomenclature, the tradition of giving definitions and names to structures and phenomena is as old as science itself. The early modern anatomist from the 16th and 17th century had to create order in the thousands of new phenomena, objects, organs and structures that they (literally) dis-covered with their new approach of dissecting human bodies and of structural analysis. Giving names and definitions is from all scientific disciplines: although very often nowadays adaptations and corrections have to be made to his taxonomy and nomenclature modern biologists still base their nomenclature on the work of Carl Linnaeus in the 18th century.

The criteria the early anatomists applied for their notions and names were in the very beginning of anatomy as a scientific discipline, purely anatomical, topographical and morphological criteria. Very soon, when other scientists also started to understand anatomy functionally, there came up also functional names and notions. Of course the names that were allotted, originated from and fitted in the scientific paradigm and state of the art in that given epoch. Many anatomical names are only understandable from that context. How else would you be able to understand the notion *processus mentalis* (which literally means "spiritual protuberance") for the human chin, if you don't know that in those days the chin on the mandible was considered to be an exclusively human feature and that most anatomist were convinced that human beings shared with animals a 'soul' ('anima') but more than that also possessed a spirit (the word 'mens' is Latin for spirit). The name *vena saphena* was probably derived from Arabic language ('el safin'), a word meaning something like 'hidden' or 'covered'; others state it is derived from the kind of an opposite Greek word 'safaina' ('manifest'').[1] Names like *biceps* muscle, *scalenus* muscle, *sartorius* muscle and even notions like hippocampus are derived from form analogies. These examples also show that a lot of the names in anatomy that have been established, nowadays actually are no longer valuable but that, because of tradition (a haunting phenomenon in circles of scientists) they are still practiced with the feeling of consensus: "Everybody in the field knows what you mean". How many neurophysiologist nowadays know that the hippocampus is named because for the first anatomists dissecting the brain this structure looked like a sea horse? Often however there exists the risk of ambiguous or contradictory interpretations of names, if people have

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http://dx.doi.org/10.1016/j.jbmt.2015.01.002

[1] Interesting that both features (in themselves controversial) may both be considered to be typical for this large subcutaneous vein in the thigh region. That the origin of the name is so old (far before the century of Vesalius) has to do with the fact it is one of the few veins one may observe with the bare eye in living human bodies).

different interpretations to the given name. Referring to the theme of this essay, the word 'fascia' for example originally meant bundle, — a band around a string of hair for example —, so the primary notion of a fascia was, and often still is, 'envelope', connective tissue that envelops a (sample of) anatomical unit(s) or organ(s) (*fascia renalis*, *fascia cruris*).

However in the days when they agreed about anatomical terminology and nomenclature there was so much they did not yet know. To name a muscle as biceps muscle is a typical argument of shape, a typically topographical name, it does not express anything about the function of the related muscle. Although names like *flexor digitorum muscle* are efforts to interpret the forms as functional, they still fail in their meaning because the muscle in this example does not only bend (flex) the digits, it also assists in flexing the wrist joint and even the elbow joint. Nowadays we know and understand much more about muscles and their functions and although thereby exists in the general public a very widely spread notion that we move by means of contractions of muscles, every (neuro)physiologist and functional anatomist knows better. We make movements with our so-called Posturing and Locomotion System PLS (or Apparatus) and for that we organize and orchestrate the activity of muscles. The so-called musculoskeletal system (where is the connective tissue in this notion?) functionally is a free term but an apparatus consisting of muscles and bones (and ligaments and other connective tissue structures) has no functional meaning without an organizing nervous system. The spinal cord and brain stem at least can be considered as integral parts of a PLS in abroad sense (*sensu lato)*. The PLS is 'organized' functionally in movements not in muscles: "The brain knows nothing about muscles" is now the modern slogan amongst neurophysiologists. This means that in modern functional anatomy and physiology muscles are no longer considered to be the units of movement, and very seldom the function and form of a muscle are 'one to one'. But still the old view is haunting us in textbooks. In my 35 year career as anatomy professor at several universities in Holland I for example always have 'forbidden' my students to talk about the "respiratory muscles" as the physiologist in our faculty did. Respiration is a functional category, not an anatomical category and certainly not a topographical one! There are no exclusively "respiratory muscles"! There exist dozens of muscles with which you can exhale, or better which you may apply in the act of exhalation, also depending on how you stand, sit or lie. And even those so-called true 'respiratory muscles' like the intercostal muscles, are more important in functioning as the dynamic elastic component of the thoracic cage, preventing the wall from being sucked in, or blown out, following the negative and positive pressure created during breathing. The related terminology of primary and auxiliary respiratory muscles is even more functional nonsense. Considering a diaphragm (*diaphragma thoracis*) as an exclusively or typical respiratory muscle, completely denies the role it plays in standing upright, in lifting your child from the ground by means of your diaphragm. One of the most important so-called auxiliary respiratory muscles, i.e. the *quadratus lumborum* muscle, that is functionally very important in assisting to active exhalation, however has a typical anatomical name based on its shape and location, and is in nearly all anatomy books categorized as a muscle for lateral flexion of the trunk.

So many muscles are involved in a variety of different movements, and actions. Still in the nomenclature of muscles there often is great confusion as to the functional criteria associated with these names? Why do so many anatomist still categorize in their textbooks muscle groups, such as the anteflectors and retroflectors of the leg? Anteflexion and retroflexion are physiological criteria, anatomists should talk about ventral and dorsal muscles of the leg, because that is what they anatomically and topographically are. And the ventral muscles of the thigh are not synonymous with the muscles with which you anteflect your leg. Or with the parts of muscles which you may recruit in the act of anteflection. Since the seventies compartmentalization of muscles is a common notion in the field of kinesiology. Even on the level of innervation and brain organization the (sub-) compartmentalization of muscles is a fact. In general it is more logical and functional to consider **motor units** and not muscles as the units that are recruited when you perform an action or make a movement. More important as to the slogan "the brain knows nothing about the muscles" is that we *learn* in movements, You learn to raise your leg from the table, which is, when you lay on your back an anteflection and when you lay face down is a retroflection.

Names are important, they help us to exchange information and definitions. But names also often originate from a given period or from a paradigm that years later no longer is valid. Yet we manage with the old terms, while knowing and realizing that they are not what they seem to be. In the meantime however there is a risk that we no may longer be talking about the same thing. An example from the domain of embryology may elucidate this. How great has been the misunderstanding when the early embryologists started to apply names (terms) like gill folds, tails to the homologous forms in the human embryo which has turned out to be an absolutely wrong functional concept. It was in the days that evolutionary biologists defended the notion that ontogeny was a kind of recapitulation of phylogeny. Homology is a very dangerous notion because things may look the same, but that does not mean that they are the same in functional or biological respect. The whole modern neurophysiology is framed into a completely irrelevant and obsolete anatomy. Yet we work with it. The anatomy of the brain was first described and revealed by ingenious people that had not any notion of the function or meaning of the structures they described! That is why we nowadays have our short memory functionally localized in a sea horse (hippocampus) or a tail-shaped organelle (caudate nucleus). Just as the term 'biceps' had nothing to do with the function of that muscle, so a hippocampus as nomenclature has nothing to do with short memory. But we all can still apply those names because "Everybody in the field knows what you mean".

But what if that latter consensus slogan is no longer valid! Take the *fascia cruris*. In many dissection manuals this "structure" is still described as a layer of connective tissue that envelops the bones and muscles of the foreleg and that one has to 'remove' to make the underlying structures visible. [By the way, please realize that in principle this was what the anatomical mind was about: making visible, show what in the living body was meant to be hidden or invisible!] So in this case the fascia is considered to

be a cover so to say. Implicitly to that is the notion that the *fascia cruris* is an envelope around muscles and bones of the foreleg, and therefore contains and envelops. The surgeon confronted with a so-called 'compartment syndrome' (swollen and edematous ventral muscles of the foreleg after too long and too heavy exercising of the leg by untrained people or caused by hematomas) knows what to do! Fasciatomy! Cut it open in order to give the swollen tissue way in order to prevent compression of the arteries and necrosis. But every medical student who ever dissected a fascia cruris could have observed that in the proximal portion of the foreleg it is evidently more difficult to 'remove' the fascia whereas in the distal portion of it this is not that difficult at all. Proximally hundreds of short muscle fibers of the extensor (sorry, ventral) muscles of the foreleg are inserting to that strong collagenous connective tissue layer. This phenomenon therefore functionally 'changes' the envelope into an aponeurosis conveying tensile forces to the skeletal elements so that the area from which muscle fibers of those ventral foreleg muscles may originate can be much larger than just the available periost. This on its turn is profitable for the "construction" of so-called pinnate and therefore powerful muscles in the area. Another well-known example. Nearly every expert knows that the ilotibial tract is a special part of the *fascia lata* functioning (just like the proximal *fascia cruris)* in the conveying of tensile forces from amongst others the gluteal muscles to the skeleton of the foreleg and the reverse. The ilotibial tract certainly is not the envelope that the *fascia lata* indeed mainly represents, but rather is an aponeurosis or flat tendon (or a good example of a "dynament"? *Vide infra*). But who really assumes that there exists a connective tissue strand running from the iliac crest of the iliac bone to the lateral condyle of the tibia, configures a structure that even cannot exist in the context of bipedal locomotion. If a stiff layer of collagenous connective tissue was running between the crest and the condyle, then adduction in the hip joint would not be possible to the slightest degree. So in this case the name is anatomically, functionally and conceptually false.

Collagenous connective tissue structures are not elastic like so many popular anatomical models of so-called ligaments seem to show. Ligaments are constraints, non-flexible and non-adaptive structures (here the phenomenon of hysteresis is not taken into account). Ligaments are defined to be strong and tough collagenous connective strand between two skeletal elements. But anatomical structures like the radial and ulnar collateral ligaments in the elbow as they are generally depicted in anatomy books, do not and cannot exist per se! The organization of such guiding structures implies that the insertion point on the one bone and the origin point on the other in every position of the joint has (maintains) the same distance to each other (equidistance). In some exceptional cases like the cruciate ligaments in the knee that is the case. But more often the connection between two articulating and moving skeletal elements should be adaptive and flexible, therefore cannot be constituted by dense collagenous connective tissue alone. In extensive studies in the 80's of the last century in Maastricht, Holland, it was clearly demonstrated that very often the peri-articular connective tissue is organized in series with muscle tissue, in this way constructing so-called 'dynamic ligaments'. The same is true for an ilotibial tract: in series with fibers of the *gluteus maximus* muscle it represents a dynamic lateral force transmitting system which is anatomically but not functionally a part of the fascia lata.

Dissecting the dorso-ventral forearm muscles provides a good example of the problem one meets if one wants to describe and name the connective tissue structures that are found. The principle of organization of connective tissues in general and of fascia in particular is more often (trans-anatomical) architecture and continuity, and not (discrete) anatomy. But if one wants to describe this architecture in the given region one immediately becomes restricted by the given anatomical terminology. In between the mentioned muscles there are connective tissue layers, distally consisting of loose areolar connective tissue in order to enable gliding movements in between the related muscles, proximally however there are very strong, dense collagenous connective tissue layers that are involved in force transmission between the muscles and the skeletal structures where those layers are inserting. In anatomy books such layers are considered to be inter-muscular septa. This functionally however means that those proximal intermuscular septa function as "tendons". As to nomenclature, tendons can be attributed to a given muscle, but how to name those inter-muscular tendons? Even the so-called antebrachial fascia in this area functions as a tendon or aponeurosis of those dorsoventral forearm muscles. This example shows that the architecture of the fascia in the PLS relates to the anatomy of the "muscleman" as warp to woof. A "musculoskeletal" system can be considered as being "built-up" from elements, i.c. muscles and bones. The architecture of the fascial system escapes this anatomical principle. Sometimes people refer to the fascia as a so-called "connective tissue skeleton". This however is a paradoxical terminology: the skeleton consists of separate elements, in the fascia continuity is the key word.

What is in a name? Very much! What is in a name? Nothing. For connective fascial structures it apparently is not enough to state WHERE a certain connective tissue structure is situated but, in order to understand its functional role and meaning, it also is important to know HOW it is mechanically related and organized in the context of neighboring structures and tissues. That is why in many studies in the last decade it was emphasized to not study the anatomy (topography) of fascia, but its architecture. This even seems to be a necessary prerequisite in understanding the role of fascia in proprioception (Van Der Wal, 2009, 2010). The architecture of the fascial layers is instrumental in the process of proprioception. And often several functions can be combined or united in one component. Of course the fascia lata and fascia cruris are very important envelops able to give resistance against the contracting muscles inside, in this way creating the mechanism of the 'muscular pump' pushing the blood towards the heart in the subfascial peripheral veins. The envelope function is however partly combined with being an aponeurosis to inserting muscle fibers. This not only happens in the forearm region, but also in the proximal crural fascia and at the dorsolateral portion of the fascia lata where it is continuous with huge intermuscular septa which mainly function as aponeurotic layers for underlying muscle fibers. The ilotibial tract is a good example that a part of a

fascia also might have a ligamentous function (albeit in a dynamic way) which is not immediately related to the muscle which this fascial layer is the covering.

In the brain topography is not the issue but anatomical connection is the essence. So it is with connective tissue, with fascia. A functional division of the brain in levels of evolutionary functions resulted in the concept of paleo-arche- and neopallium. These are on the one hand global anatomical notions (e.g. deep and superficial), on the other hand they represent developmental as well as functional categories that apparently completely transverse the classical anatomical subdivision of the brain in, for example, cerebrum, cerebellum, brain stem and similar anatomical units. A term such as 'limbic system' is an effort to describe functional units in the brain in which the topographical relationship is no longer considered, but rather *how* they relate in terms of stimulating or inhibiting connections. Modern neurophysiology works with the old anatomical notions but even there the architectural component has become more important for understanding the function of the brain. Architectural thinking is a form of contextual thinking, anatomical thinking is about isolating and discriminating structures. Therefore the anatomical mind is not the best one to describe the organization of brains and of … fascia.

Is there a need for a new fascial nomenclature?

Is there a need or a necessity for the community of scientists and practitioners involved in the fascial system to develop a complete up to date nomenclature as to fascial anatomy and its components? I don't think so. The best pragmatic solution is to look at the neurophysiologists. They use and apply the old terminology of the neuroanatomists and compose those anatomical elements into new functional circuits. So, in the case of fascia, anatomy is the warp and architecture the complementing woof. This simply means that one can describe the fascia in its position in between two anatomical structures for example muscles, but that this is not enough. For understanding the connective tissue structure functionally, is not only necessary to describe *where* it is organized, even as important is the notion of *how*. Is it loose areolar connective tissue enabling mobility or strong, or collagenous or dense connective tissue transmitting forces?

Connection, context, architecture is the item. But then you come to problems as an anatomist who learned (and teaches) that muscles and ligaments and bones are discrete elements. They are not. But for the nomenclature addict the first simple intermuscular septum is already a nail in his/her coffin. That is because a tendon can be attributed to a given muscle (the muscle is organized around the tendon, so to say) but an intermuscular septum, one of the major appearances of fascia, is something else. Here the fascial elements are not situated centrally in a muscle but from both neighboring muscles, fibers are oriented to that connective tissue element, which therefore is not an anatomical but a transanatomical element. So do not formulate new names but be aware that of every fascia part and layer you have to ask yourselves two or three important question, what are the criteria? Do it with the old anatomical names and notions but (like the brain physiologists do) formulate their functions (architecture). The classical fascial (enveloping) function is not always what it is. It is gliding and/or force transmitting and/or creating intrafascial pressure for blood pump and so? What kind of mechanoreception is providing the type of information that this fascial layer is contributing to the function of proprioception? Is not purely an anatomical but an architectural item (Van Der Wal, 2009, 2010).

In 2009 at the second International Fascia Congress a good effort was made to come to an agreement as to a kind of nomenclature about the functional histology and anatomy of fascial 'structures' and types of fasciae. That I consider to be a good effort but even there one has to deal with the semantic problem of categorizing "apples and pears". "To foster the communication", Langevin and Huijing (2009) suggested in an article twelve specific terms to describe specified aspects of fascial tissue:

- Dense connective tissue
- Areolar connective tissue
- Superficial fascia
- Deep fascia
- Intermuscular septa
- Interosseal membrane
- Periost
- Neurovascular tract
- Epimysium
- Intra- and extramuscular aponeurosis
- Perimysium
- Endomysium

The problem here is that the list is incomplete (why is interosseal membrane included and not 'ligaments'?) and inconsistent: some terms are about the quality of connective tissue like areolar, elastic, dense (collagenous), other notions like intermuscular septa, endo-, epi- and perimysium are more anatomical categories. Terminologies like periost and perimysium have nothing to do with functional histological criteria and are in fact anatomical notions. Here again the confusion and mixing of the Where and How criteria is threatening. Here also the advice has to be: always use in your description the anatomical (where) AND the architectural (how) criterion.

Last but not least there is a problem: should fascia also be considered as an organ or a system? What did AT Still actually mean with a notion such as "the soul is dwelling in the fascia"? Langevin and Huijing (2009) suggest: "To ease communication and minimize ambiguity, we suggest that the term "fascia" should not be used by itself — that is, without further definition or refinement because it is not clear whether this term refers to an anatomic entity or a type of tissue". That in my opinion is too simple: in particular in circles of osteopathy the term 'fascia' has become so well-known and practical that the proposal to abandon it would deeply disturb the practitioners and impede their communication.

On the other hand the term fascia as applied in those circles is still very vague, anatomically not well defined, multipurpose and multi-interpretable. It seems, as Langevin and Huijing (2009) state, "that this confusion of terms is not new and unique to our times at all, despite the fact that Hyrtl (1880), before giving an explanation, states

that "nobody needs an explanation of the word fascia" but nevertheless gives one to be complete".

Maybe we should give up the effort to employ and establish an absolute, watertight definition and description of the term fascia and do we have to accept that, as in notions such as blood or locomotor apparatus, sometimes two or three interpretations and applications of certain terms are possible and practical. One could talk about a locomotor system or locomotor apparatus but also about a Posture and Locomotion System (PLS). So the term however could have an interpretation in smaller sense (*sensu stricto*) or in a broader sense (*sensu lato*). Considering the notion locomotor system or locomotor apparatus, one may discriminate between the *sensu stricto* definition like many anatomical textbooks apply, and the more *sensu lato* definition which will include the necessary central nervous system (for example, spinal cord).

In anatomy books a special chapter is usually dedicated to the bones (skeletal elements), another chapter to the muscles (muscular elements) but there is no partitioned chapter dedicated to "the connective tissue skeleton". Some authors comment the usual notion (as applied in anatomy) of musculoskeletal system asking the question Where in this definition is the main component of that system i.e. the connective tissue i.e. the fascia? The term musculoskeletal system apparently is too poor but still we all know what is meant by it. It is extremely difficult to get this term expelled from anatomy textbooks. To talk about a Muscular, Connective tissue, Skeletal system (MCS) (Corcos, 2014) might be a step in a good direction. But also then the question remains What is "the fascia" or What is "fascia"?

Modern concepts as to tensegrity demand the musculoskeletal systems to be organized in two components, i.e. the stiff pressure forces conveying on the one hand, and flexible tension forces transmitting on the other. This concept more or less induces a view on the PLS (Postural and Locomotion System) as organized in skeletal elements versus so-called "dynaments" (units of muscle and connective tissue) (Van der Wal, 2009, 2010). Could muscular tissue also be considered as a component of a "fascial system", at least when we apply this term in the context of fascia as a tensional network? The latter term is derived from a recent book about the fascia: *Fascia*: *The tensional Network of the Human Body* (Schleip et al., 2010).

There is however more. The fascia as a system is not only restricted to the so-called musculoskeletal system or the PLS. In osteopathy emphasis is also laid upon a sort of visceral fascial system related to the organization of the mesothelial connective tissue i.c. peritoneum and its plicae and folds ('ligaments'). So, does this connective tissue also belong to the fascial system? Indeed one could consider the body cavities and related 'meso' as the organization a visceral connecting and shaping space.

A way to elucidate the philosophical problem which is at stake here, is to apply the same questions to blood. Is blood a tissue? Is blood an organ? Do we talk about the blood system? If yes, is that organ "blood" completely synonymous with the notion of the cardiovascular system? There are good arguments to consider the blood as an organ. And that it could even be described as analogous to the fascia or fascial system. Because the fascia as the organ of connective tissue is functional in the spectrum between connecting and binding on the one hand and shaping space and enabling motion on the other. The same is true for blood: considering the thousands of miles of capillaries in our body as an organ, one could express that the function of this organ also is connecting and shaping space between the different organs and body parts - blood as mediator, distributor and controller in the internal and with the external environment of the body. Whereas the fascia is doing this in a mechanical way, the blood is doing so in a physiological way. In this respect it is noticeable that in the embryo the first manifestation of the 'meso' (usually mentioned as 'mesoderm') is nearly always the combination of primitive connective tissue (mesenchyme) and primitive capillaries. One could consider the blood compartment as a specialization of the interstitial compartment of the body. For as well as blood, as well as connective tissue (re-presenting here the main component of the interstitial compartment) we could state that architecture is the organizational principle: as a matrix organ the fascia (connective tissue) is "everywhere" which is also true in a way for the blood organ. Intriguing in this context is that the blood (capillaries) as well as mesenchyme are the first functional appearances of the meso(derm) germ layer. Germ layers mostly are considered to be three anatomical principles and most embryology books try to describe which organs in the body are derivatives from which germ layer. The germ layers however are also functional principles. Blechschmidt's proposal to no longer consider the meso layer as "one of the three" is about to attribute to the meso(derm) the function of "innerness" "Inner tissue could therefore be described as undifferentiated connective tissue" (Erich Blechschmidt, p. 64).

No organs exist that are exclusively composed from ectodermal or endodermal components, there is always meso in the form of connective tissue and blood. Blood is a system, therefore (sub)organized in organs. Therefore it is mostly indicated in the category of cardiovascular or the blood circulation system with heart and blood vessels as organs in which certain functionalities of the blood are concentrated and specialized. In this way the fascia could be described as a system of (mechanical) connecting and shaping space in which – perhaps – muscles (or muscle tissue) could be incorporated as organs (or tissue) specialized in dynamic connecting and shaping space (contraction and relaxation). This might sound disturbing and yes it is. At least it honors the matrix character of the fascial organization. A challenge as well as a torment for those who always prefer to categorize the parts of the body, but also the semantic step in the direction of the more holistic concept to consider the fascia as the "organ of innerness".

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