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Review

Epimuscular myofascial force transmission: A historical review and implications for new research. International society of biomechanics Muybridge award lecture, Taipei, 2007

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A B S T R A C T

Elements of what we call myofascial force transmission today have been on peoples mind for a long time, usually implicitly, sometimes quite explicitly.

A lot is there to be learned from the history of our knowledge on muscle and movement.

There is little doubt about the presence and effectiveness of the mechanism and pathways of epimuscular myofascial force transmission. However, we should learn much more about the exact conditions at which such transmission is not only of fundamental biomechanical interest, but also quantitatively so important that it has to be considered for its effects in health and disease. Even if the quantitative effects in terms of force would prove small, one should realize that this mechanism will change the principles of muscular function drastically.

A new vision on functional anatomy, as well as the application of imaging techniques and 3-D reconstruction of *in vivo* muscle, will aid that process of increased quantitative understanding, despite usual limitations regarding the mechanics in such experiments. I expect it is fair to say that without understanding myofascial force transmission we will never be able to understand muscular function completely.

Contents

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1. Introduction

This review will focus specifically on paths of force transmission arranged *in parallel* to the myotendinous path of force transmission to bone: i.e. myofascial force transmission. This transmission is called that because supramolecular chains of connections (for a review e.g. Berthier and Blaineau, 1997) between the myofibre cytoskeleton and the collagen reinforced extracellular matrix allow force transmission between cytoskeleton and endomysial–perimysial–epimysial muscular connective tissue stroma. Not widely considered regarding its consequences until molecular biology gave us more information regarding the nature of the connections, a few groups under the direct pressure of unexplained experimental and morphological results have been working on this phenomenon for a few decades (Eldred et al., 1993; Hijikata and Ishikawa, 1999; Hijikata et al., 1993; Loeb et al., 1987; Purslow and Trotter, 1994; Street, 1983; Street and Ramsey, 1965b; Trotter, 1990; Trotter and Purslow, 1992; Trotter et al., 1995). We categorize the type of transmission discussed in these papers as intramuscular myofascial force transmission (as it deals with force transmission within the confines of the continuous epimysium and epitenon enveloping muscle and its tendon(s)).

1.1. *Epimuscular myofascial force transmission*

Epimuscular myofascial force transmission is defined as the force transmission between muscle and its surroundings, passing via the outer limits of muscle–tendon complexes (epimysium).

My personal first encounters with such ideas (Huijing, 1999) showed that intramuscular myofascial force transmission occurred in rat extensor digitorum longus (EDL) muscle after progressive distal tenotomy (Huijing et al., 1998) and that partial blunt dissection of the perimysium separating the different heads of EDL removed most, but not all, of the effect. We were struck by the structural similarity of intra and intermuscular connective tissues and the ease by which they could be broken by blunt dissection. Because of that we speculated that similar force transmission would be possible between muscle and its surrounding muscular and non-muscular tissues! After this particular publication my research group set out to explore that almost unbelievable possibility and to test it experimentally.

1.2. *Purpose of the present work*

The purposes of this article are threefold: (1) to test, by historical literature study, if ideas related to myofascial force transmission are not quite as modern as one might think. Some ideas that are a least related to force transmission are reviewed, and so or some historical examples dealing with it specifically, (2) to consider consequences for further research and (3) to, review, briefly, the most salient features of epimuscular myofascial force transmission. Due to the limitation of space, a more detailed representation of this part of the Muybridge lecture will be published elsewhere (Huijing, 2009).

2. Some historical aspects of myofascial force transmission

In relation to this subject, I have been particularly inspired by a number of quotes:

Beautiful are things that one sees, More beautiful are the things that one knows, By far the most beautiful are the things that one ignores. Stensent (1673)	If you know something, then say 'I know'. If you don't know, then say 'I don't know'. Then you really know Confucius 551–479 B.C.

Niels Stensen is an important scientist in myology, as he was among the first to consider muscle in terms of a model, incorporating the phenomenon of constant muscle volume, and to consider myofibres as independent sources and agents of movement.

At the XXI ISB congress in Taipei, Savio Woo appropriately presented a quote of Confucius in Chinese, indicating that true knowledge involves awareness of what one does and does not know. Evidently, knowledge of this kind is ancient wisdom. The translation shown above was provided by my colleague and surgeon Dr. Hu, who is a citizen of China and presently a researcher in our faculty.

John Gerould is an historian of the sciences, who published on the ideas of, what we today call, connective tissue. He expressed the following:

> How often it happens that a great discovery, before it finally flashes out upon the world, smoulders for a long time in men's minds, dimly understood, its full significance unfelt!,
>
> John H. Gerould (1922).

In retrospect, these quotes seem applicable to the development of the ideas concerning myofascial force transmission and more particularly epimuscular myofascial force transmission. Ideas, related to this concept, have been popping up throughout history of the medical–biological sciences.

2.1. *Connections between nerve and blood vessel connective tissues and muscle*

As neurovascular tracts embedding and (collagen) reinforcing the blood and lymph vessels and peripheral nerves are important candidates for being a major path of force transmission, we should consider detailed description of these structures as a starting point. Ancient Greeks had access to such descriptions (because of the work of, e.g. Galenos (129–210)) (In Greek, with Latin and French translations available since the 16th century, e.g. Galenos, 1538, 1541; Galenos and Canappe, 1541).

However, the Renaissance-induced changes, enhanced anatomical activities. A number of anatomists must have spent considerable time dissecting blood vessels and nerves of the human body. Images of these structures were made by Andreas Vesalius, who revolutionized anatomy, but in the 16th century