Muscle Biomechanics in Coaching Practice

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INTRODUCTION

In the 60´s and at the beginning of the 70´s the first studies about the role and value of the muscle elasticity in the action of the human motion system have appeared. Some authors (Bosco, Cavagna, Asmussen, Komi and others) who more intensively studied this problem together with kinesiologists later followed up the original physiological studies on the muscle contraction and step and step developed the proper biomechanical style. Although the initial stimulus came in fact from sport, we can say now (nearly after 20 years) that this effort has not carried out any expressive enrichment to the coaching practice. It is not difficult to answer the question why it is so: the contemporary knowledge and theories are on a such level which is not suitable to yield necessary explication and generalization for their practical applications. It is possible to suppose that cause of that state is the insufficiency of the science. It is clear that such complicated problem biomechanics are not solved. Therefore usually used terms in coaching practice are either connected with the original kinesiological meaning describing the kinematical aspects of the movement (as isometric, isokinetic, flexion, extension, rotation etc.) or related to force (isotonic, explosive force, static force etc.). Nevertheless their practical interpretation is very often disunited and mainly inexact. The usual neglecting of the information role of the sceletal muscle perhaps results in practice to the simplified imagination of a muscle as a source of the mechanical energy only. This simplified static approach does not differentiate the excitation dynamics, variability of the mechanical properties and especialy the aspects of the muscle unit intramuscular cooperation. It leads to the excessive accent on the force and velocity of the contraction based on earlier physiological findings.

THE FUNCTIONAL MECHANICAL MUSCLE DIFFERENTIATION

Apparently it is possible to anticipate, that the muscle as the system with the controlled inner mechanical properties, will widely change its mechanical behaviour with respect to an outer mechanical loading. This is easy to assure based on datum described on the Fig. 1. In accordance with the impedance theory the force is related to velocity by mechanical impedance. A muscle behaves as a system with controlled inner rheological like characteristics. Its elasticity predisposes its ability to mechanical energy storage, its viscosity predisposes its dissipation function. Both these muscle abilities play the important role in the muscle game against am outer load, and result in a general actuating or breaking role.

The general importance of the potential energy storage for the correct function of the joint was several times experimentally documented (e.g. 1, 2, 3, 4, 8, 11, 19). Already there is no doubt of the importance of the muscle and tendon elasticity in that process. Because the elasticity is a basic component of the oscillatory circuit, it seems that the presence of the oscillatory phenomenon in some movement situations is indisputable as well (6). The function of the mechanical oscillator depends also on the mass and dumping, which in the case of muscle strongly depends on its active state. Therefore muscle dumping has great importance to the reliable and efficient function of the movement system Fig. 2.

From these results the partial conclusion may be made that control of the muscle coordination play a conclusive and final role in the complex movement performance. The hierarchical superiority of the control aspects operates during training on each of levels of the adaptive process of the human organism. In its consequence it is e.g. the evident functional facilitation of some muscles (see Fig. 3). In this connection it is possible to raise the question: in what way will the coaches choose to compromise this problem?

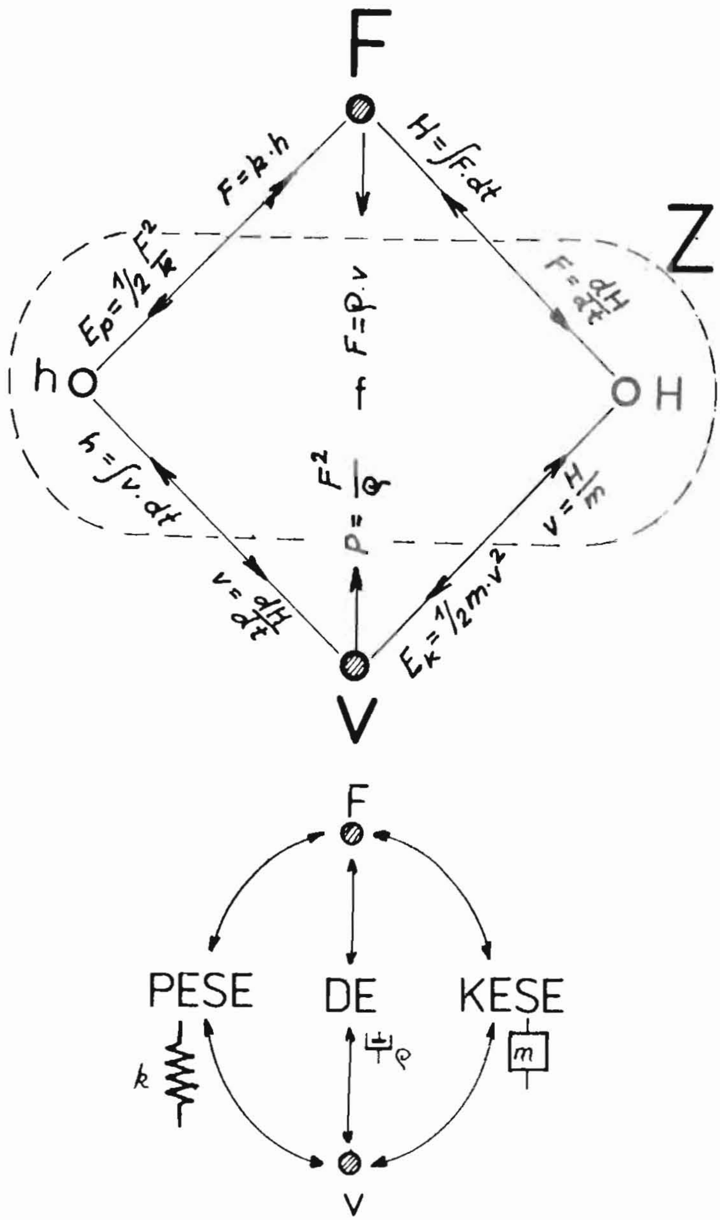

Fig. 1 Diagram of the relations of the basic mechanical state variables (F-force; v-velocity; h-displacement; H-momentum; Z-mechanical impedence; f-friction; PESE-potential - energy storage element; KESE-kinetic - energy storage element; DE-dissipative element).

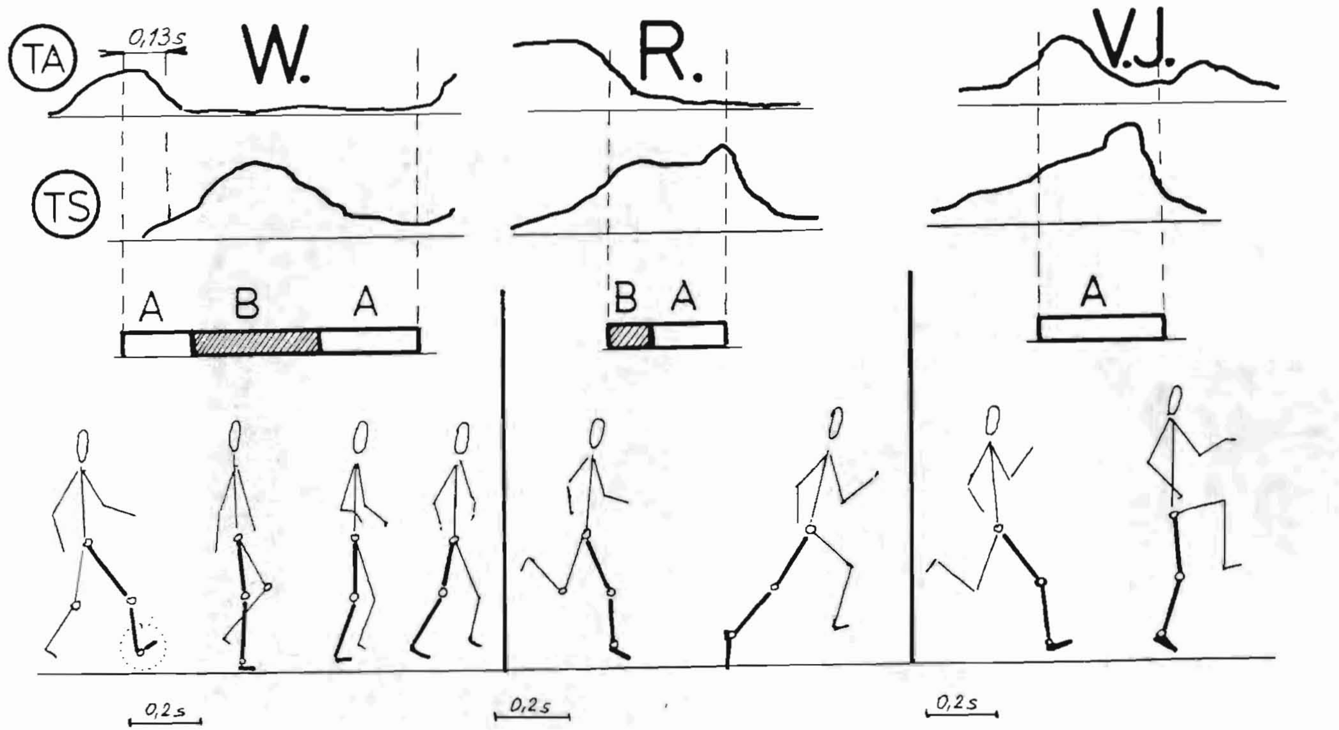

Fig. 2 The asymetry of the m. psoas major accasioned by the unilateral training loading (CT cuts of the pelvis area of the high performance lifter).

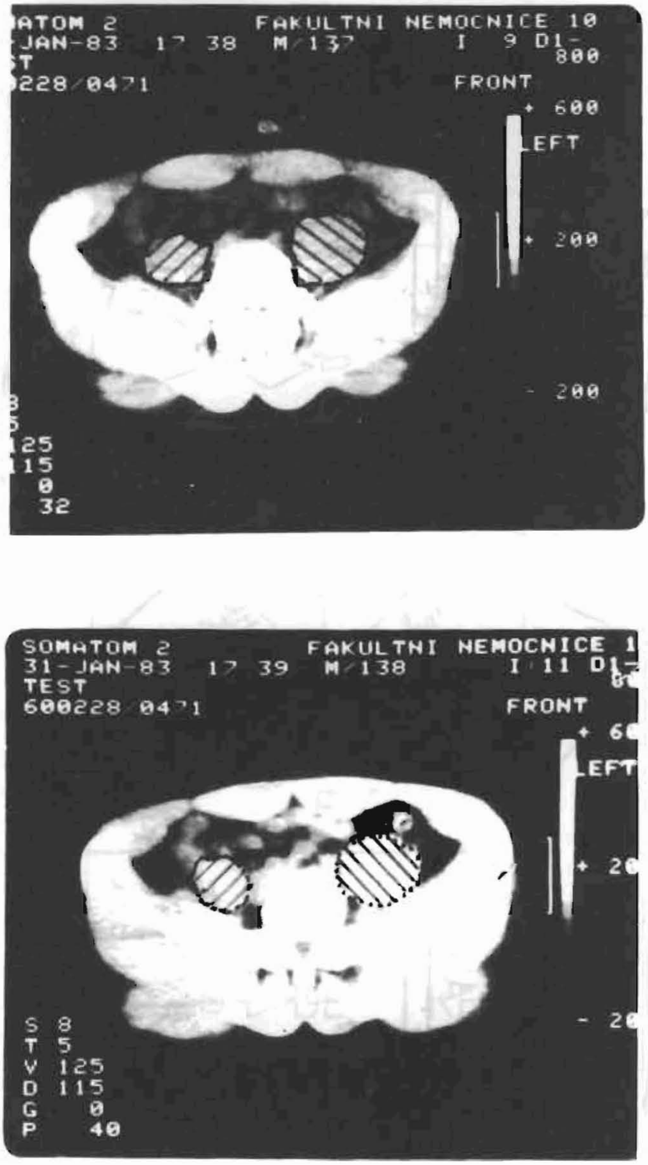

Fig. 3 The time course of the active states of the m.tibialis anterior (TA) and m.triceps surrae (TS) during the time of the contact of the right leg of the walking (W), running (R), and vertically jumping (VJ) athlete. The active state is expressed by means of rectified EMG (A-actuation, B-braking period).

DIAGNOSTICS OF CONTRACTION DYNAMICS

The proper process of an active state development is reflected in the mechanical response of the muscle units activation control. The evaluation of the contraction dynamics is usually made by the quantification of parameters which are related to the time course of the force response, evoked by defined stimulus against defined outer loading. There is the usual reaction time, electromechanical delay, force gradient, maximal force, time to reach a half of maximum force, force - velocity relationship parameters and others. Some of them characterize rather steady state events, the other characterize rather nonstationary processes (11, 16, 15, 10). In case of voluntary contraction the values of these parameters reach intraindividual dispersion (until 100%) which overlaps any trace of the searched interindividual difference. Therefore, critical approach to such results is necessary. If the active state is evoked by electrical stimulation, the variation coefficient of the response parameters abruptly decreaces. The stochastic character of the muscle unit recruitment which belong to the first type of activation is the cause of the large indefiniteness of the muscle force response. It means that influence of the CNS upon the muscle contraction dynamics is dominant. It could be seen very well on the frequency-response characteristics which reflect the transfer function character of the neuromuscular plate - muscle - tendon - body segment system or the same system extended by CNS during voluntary contraction (10, 15, 16).

The above mentioned facts formulate some partial methodological conclusions for coaching practice:

a) Information merely on the maximal force of the voluntary activated muscle is practically worthless.
b) The parameters which are related only to steady state type of contraction (e.g. so called static force) are deficient for evaluation of the functional properties of the muscle.
c) The dynamical properties of muscle effectors are directly dependent on the kind of activation.
d) The results of the laboratory experiments indicate the closed individual nature of dynamics of the muscle twitch, evoked by the electrical supramaximal one-pulse stimulus. This nature is stabilized by the muscle morphology, position in the movement systems.

CONCLUSION

It is possible to say that the general value of the contemporary muscle biomechanics knowledge is mainly didactic. It is impossible to make a generally relevant model of muscle coordination of any kind. The laboratory results hold out hopes for coming of renaissance of skill, fitness, brisknes etc. This new approach may introduce to the coach the fundamental enlargement of methodological and metrological equipment, in particular methods for muscle cooperation analyzes.

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