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LETTER TO THE EDITORS

THE MEANING OF THE TERM 'BIOMECHANICS'

At The 4th International Seminar on Biomechanics (Pennsylvania State University, 26–31 August 1973) the International Society of Biomechanics (ISB) was founded, stating as its purpose the promotion of the study of biomechanics of movement with special emphasis on human beings.

Apart from the fact that the term, 'biomechanics', is still undefined and appears to have as many meanings as there are researchers working in this field, it is not easy to see why an international society, claiming to be representative of Biomechanics, should restrict its interest to the Biomechanics of *movement* only.

Let us deal with this point first. At the founding meeting of the ISB, a physicist remarked that he would like to see the study of the statical aspects of Biomechanics to be included in the promotion program of the ISB. The reply given was that statics is, in any case, only a special case of dynamics, namely, the case where all accelerations are zero. Hence, it was argued, that there is no need to mention statics explicitly. This argument, however, is erroneous.

Statics is defined to be that part of mechanics which deals with the equilibrium of systems *at rest* (Synge and Griffith, 1959; Bullen, 1967). Let us choose an inertial reference frame and consider an object moving relative to that frame with constant velocity in a straight line. Obviously, the object moves under zero acceleration but is *not* at rest and hence *not* static. Should the previously mentioned argument be accepted as correct, we would have to consider all objects moving with constant velocity in a straight line relative to a given reference frame to be in a static (i.e. motionless) state (relative to that frame). This clearly leads to a contradiction.

Hence, *if* one speaks about Biomechanics of Movement and *if* the purpose of the ISB is also the promotion of the study of Biostatics, then this must be stated explicitly. On the other hand, the correctness of the expression 'Biomechanics of Movement' must be questioned itself. In actual fact, this then leads us to the question of the definition adopted for the term 'biomechanics' which will now be discussed.

If biomechanics is to substantiate its claim to be a science of its own, it must:

(a) Have a clearly defined subject of study, and; (b) Obtain its results by the use of scientific methods (involving the steps, observation, experiment and reasoning).

Point (b) is a necessary requirement for any science and hence, must not be discussed any further. Point (a), however, is closely connected to the definition of the term, 'biomechanics'. There have been several attempts to define biomechanics. Some of them are rather vague or even contradictory, as discussed in a previous article (Hatze, 1971). In that article, I have also proposed a possible definition for the science called Biomechanics, which reads (translated from German):

"*Biomechanics is the study of the structure and function of biological systems by means of the methods of mechanics.*" This unambiguously defines the subject of study (point (a) above) to be the structure and function of biological systems. Of course, many other sciences investigate the same subject —but only Biomechanics does so by using the methods of mechanics.

It would not be correct to state that "Biomechanics is the study of the mechanical aspects of the structure and function of biological systems" because biological systems do not have mechanical aspects. They only have *bio*mechanical aspects (otherwise mechanics, as it exists, would be sufficient to describe all phenomena which we now call biomechanical features of biological systems). An example may illustrate what is meant by this: If we investigate the flight trajectory of a javelin for different velocities of release, angles of attack, etc. we have looked into the *mechanics* of the javelin throw. Existing aerodynamic and ballistic measurement procedures can provide us with all the data we can obtain—we can completely dispose of the athlete. The situation changes, however (and becomes much more complicated), if we become interested in the phase *before* the javelin leaves the thrower's hand. We now have to deal with the *biomechanical* aspects of the javelin throw and there are no established mechanical models, we could draw on, of a complex, nervously controlled biological system which satisfies a specific performance criterion. In order to solve this problem, we have to devise new techniques which are then specific for biomechanics. A similar situation prevails in other sciences: Bionics, for instance, the science which is concerned with the study of biological processes by means of the methods of cybernetics (Gawroński, 1971), uses cybernetical procedures for its investigations—but the resulting models are specific for bionics.

Admittedly, the drawing of sharp boundaries between the different sciences is a somewhat artificial act. In reality, there are always regions of overlap. On the other hand, if we assign a name to a particular field of research we must define what we mean by it—which immediately implies drawing boundaries. This dilemma is typical for all sciences (to-day we have subjects like Physical Chemistry and Chemical Physics). Yet, there *are* boundaries (even if not sharp) and established definitions which cannot be ignored.

Mechanics, for instance, is defined to be that branch of Applied Mathematics (or Physics) which studies the action of forces and their effects (motion or the static state). Its subbranches are Dynamics, Statics and Kinematics. Thus, if we use the term biomechanics, we must observe the established meaning of the word, 'mechanics'. For this reason it is senseless to speak of 'Biomechanics of Movement', since the term mechanics in Biomechanics by definition implies the study of motion. It does, however, make sense to distinguish between Biokinematics, Biodynamics and Biostatics.

Biokinematics (or Biophoronomy) is concerned with the

purely geometrical description of biological motions (Example: The time function of the light trace of the wing tips of a flying bird).

Biodynamics studies biological motions with special reference to the mass and forces involved (Example: The vertical force–time function during the take-off phase of a long jump). Finally, *Biostatics* may be described as the study of biological systems which are in equilibrium and at rest (Example: The pressure distribution in the trunk of a tree).

As can be seen from the examples quoted above, biological systems may consist of human beings, animals, plants or certain combinations of these. On the other hand, we may specify special areas of biomechanical activities by designating them as such. We can speak of Biomechanics of Sport, Biomechanics of Dentistry, Industrial Biomechanics, Orthopaedic Biomechanics etc.

As has been shown above, the use of the term biomechanics imposes rather severe restrictions on its meaning because of the established definition of the term, mechanics. This is unfortunate, since the synonym Biomechanics, as it is being understood by the majority of biomechanists today, has a much wider meaning. It includes not only the biomechanical (in the strict sense) aspects of biological systems, but also their bionical, biometrical (or biostatistical) and other features. For this reason, it would be desirable to have an expression for this conglomerate of disciplines which is not bound to an existing definition and which is representative of words such as kinetics, bionics, biomechanics and cybernetics. I would propose the word, *Bionetics*.

Bionetics, defined as the interdisciplinary study of the structure and function of biological systems, has a wide scope and accounts for all areas of interaction between the biosciences. The electromyographic analysis of human motion, for instance, certainly has its right place in a Seminar on Bionetics, while this may be questioned for a Seminar on Biomechanics.

The present article is not intended to present dogmatic ideas—its purpose is to put forward some suggestions for the solution of an unsettled problem and to stimulate relevant discussions.

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