BIOMECHANIKA A BIOMECHANICKÉ EXPERIMENTY

BIOMECHANICS AND BIOMECHANICAL EXPERIMENTS

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Abstrakt

Prezentovaný článok je venovaný prehľadu hlavných problémov súvisiacich s hodnotením, interpretáciou a využitím biomechanických experimentálnych údajov. Bol definovaný a popísaný biomechanický experiment. Boli navrhnuté špeciálne metódy pre hodnotenie a korekciu experimentálnych údajov biomechaniky. Nakoniec bol navrhnutý koncept korektnej transformácie experimentálnych údajov zo súradnicového systému experimentu do súradnicového systému výpočtu.

Kľúčové slová: biomedicínsky experiment, biomechanika, lokálno ortotropný materiál.

Abstract

The presented paper is meant to survey some of the main problems regarding the evaluation, interpretation, and utilization of biomechanical experimental data. The Biomechanical Experiment was defined and comments. The auxiliary methods for evaluation and correction of experimental data of biomechanics where proposed. Finally the concept of correct transformation of the experimental data from a coordinate system of experiment into a coordinate system of the computation was suggest.

Keywords: biomechanical experiment, biomechanics, locally orthotropic material.

INTRODUCTION

To get straight to the core of the problem of biomechanical experiments, we must stated what the biomechanics is. Surely the biomechanics is a mechanics. But to what is this mechanics applied?

There is the point to be considered. Now, it is clear, Rigid Body Mechanics is the mechanics of a rigid body. Solid Mechanics is the mechanics of a solid (or, if you like, deformable) body.

What about Biomechanics. Everyone knows the name Biomechanics has originated from biology and mechanics, and it in the sense: mechanics of biological body.

And the word biology means, the science of life, from the Greek bios, life, and logos, word or knowledge.

Thus, Biomechanics is the mechanics of a living body (i.e. body that is alive). Biomechanical Experiment is said to be the experimental work in biomechanics mainly producing a better knowledge of the mechanical behavior of some body segment and of the whole body under impact conditions. Yes, some body segment! But if it should be truly Biomechanical Experiment then the body segment must be alive.

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In this point of view we would debate about interaction between mathematical analysis and the biomechanical experiment that allows us to gain the better knowledge of the mechanical behavior of a living body segment and of the whole body, body that is alive, under impact conditions, but the experiment practice forces us to weaken to a small degree.

BIOMECHANICAL EXPERIMENTS

There is a wide range of truly Biomechanical Experiments in which the inverse mechanics and mathematical optimization methods play the great role. There are some presumptions about rational behaviour of living body and some measured data. On this ground the extremalization of a selected objective function, such one as minimum of the energy consumed or maximum of a movement speed.

The above described approach is well known. A similar approach is possible also in the case of not entirely pure biomechanical experiments. The experiments performed in vitro are meant. At the case of experiments in vitro the great question arises: Does the biomaterial behave in vivo in the same way as in vitro? Besides this question the great spread of in vitro eperimental data is commonly observed. Also in this case the optimalization methods may be of great use.

For example, in the case of an anulus fibrosus of the intervertebral disc there is possibility to utilize the method for laminate tube optimization by winding angle control, see [1], to predict the ratio of the first main modulus of elasticity and the second main modulus of elasticity for which the anatomical winding angle of the collagen fibres is that that maximizes stiffness.

As a matter of fact in the cited example there are some stability problems, but the illustrated method remains valid. The point being that geometry, internal structure, overall properties, average loading, fracture modes are known, at least to a certain degree, and thus a capability of a inverse analysis is widely opened to the material property estimation.

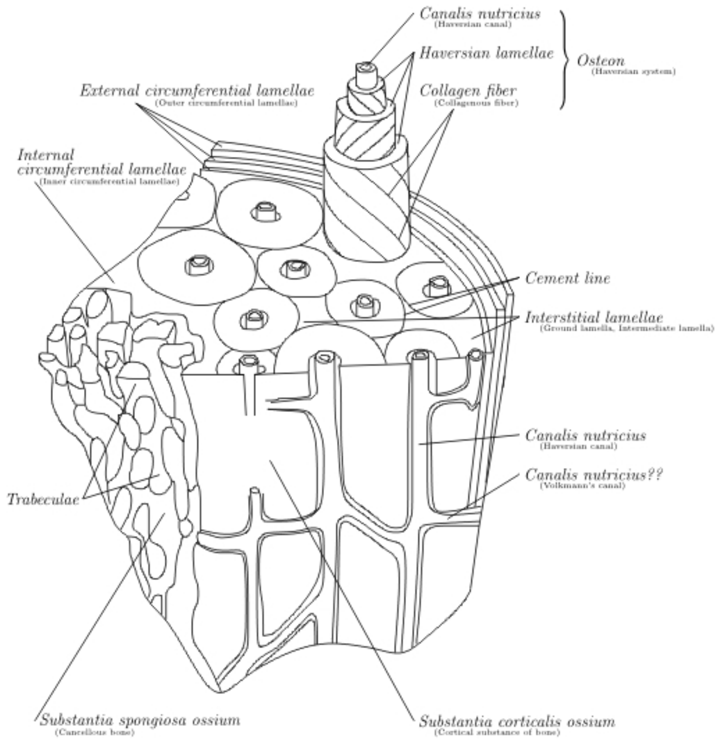

Fig.1 Sector of the shaft of a long bone

The other question is how to use results of biomechanical experiments, without regarding the data validity. There is, for example, the possibility of the elastic cortical bone coefficient determination via ultrasonic measurement, cf. [2], where the cortical bone is regarded as an transversely isotropic material. The data obtained by this way are regarded as components of the Cartesian compliance tensor. The bone being essentially cylindrical and not thin walled there is need of a sophisticated method of transformation.

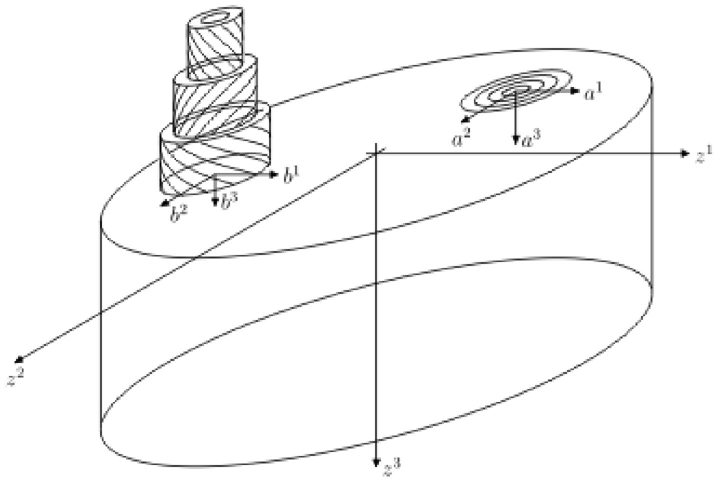

Fig.2 Coordinate systems of the long bone shaft sector

Similarly, there are some attempts [3], to apportion annulus fibrosus of the intervertebral disc into fibers and test mechanical properties of these separated portions. Once more the obtained data---data with respect to a Cartesian coordinate system---are to be transformed into the elliptical coordinates of the disc. As this case is by no means thin-walled there is once more necessity of the concept of locally orthotropic material.

Thus, let us briefly stated the concept. The nomenclature Locally orthotropic material is meant to describe a material assembled of orthogonal material parts. The point is that every part (may be infinitesimal) can be described as a orthotropic block that is in a special way transformed into coordinates of reference. the coordinate systems describing a locally orthotropic body are the so called Main frozen reference frame coinciding with main directions of the (infinitesimal) orthotropic block. These coordinates are used to describe to the body an orthogonal grid drawn through the body in a given (reference---relaxed but not necessarily unstressed---remember residual stresses) state.

Another material coordinate system that is frozen at the material in the reference state is the Globle frozen coordinate system (also named Globle relaxed material coordinate system). This system is common for the whole ensemble of othotrpic material parts. According to the reference frame constructions the transformation between the main frozen reference frame (main frozen coordinate system) and global frozen reference frame (global frozen coordinate system) shell be affine. What is essential is that these tensor components are physical quantities, i.e., quantities possessing the right units, however the coordinate systems are distorted in a reference frame of computation (Euclidian spaces with Cartesian or nonCartesian coordinates).

CONCLUSION

The presented paper is meant to survey some of the main problems regarding the evaluation, interpretation, and utilization of biomechanical experimental data. The Biomechanical Experiment was defined and comments. The auxiliary methods for evaluation and correction of experimental data of biomechanics where proposed. Finally the concept of correct transformation of the experimental data from a coordinate system of experiment into a coordinate system of the computation was suggest.

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