NUMERICAL MODELS AND HARDWARE DUMMIES FOR SIMULATING WHOLE-BODY VIBRATION OF HUMAN - AN OVERVIEW

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Introduction

The goal of biodynamic models is to simulate the vibration behaviour of the human body. In combination with experimental studies biodynamical models can be a powerful tool for the analysis of the effects of vibration exposure on health [1] and comfort. This paper gives an overview of the state of the art of biodynamic whole-body vibration models of humans, addressing both numerical models and hardware dummies.

Method

Two approaches are distinguished, the phenomenological and the anatomical, as illustrated in Figure 1.

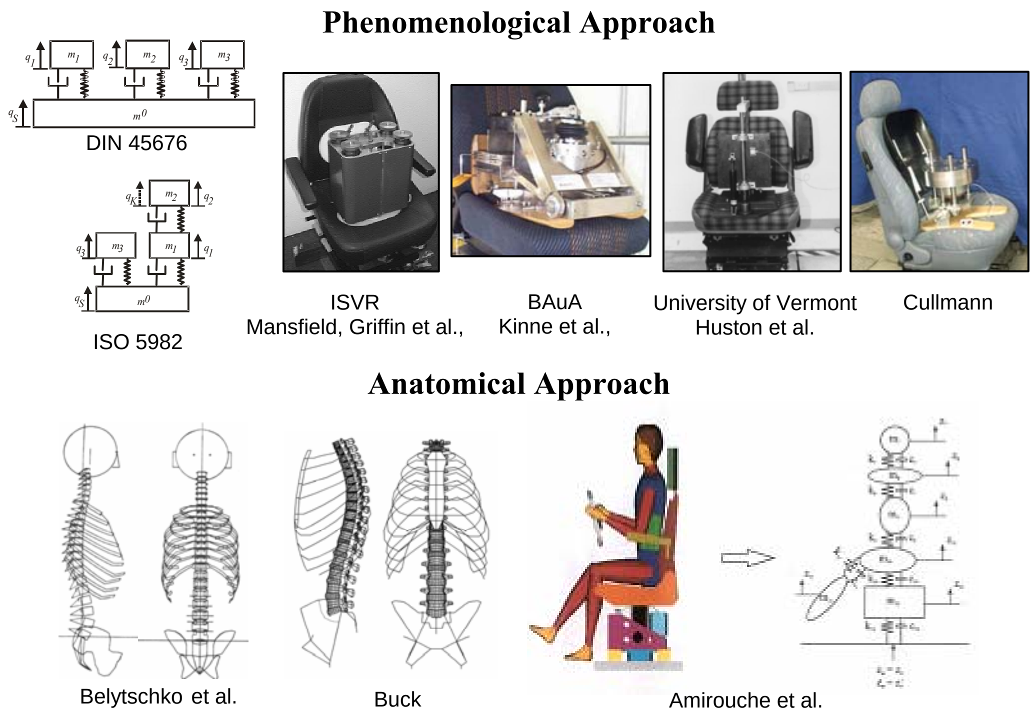

Figure 1: Two modelling approaches.

Phenomenological models aim to reproduce the vibration behaviour of humans with respect to particular physical quantities, chiefly the driving-point impedance at the interface to the seat, and partly with respect to other transfer functions. Discrete systems of masses, springs, and dampers with several degrees of freedom whose topology and parameters are determined by structure- and parameter identification methods are used in the sense that the functions derived from measurements are reproduced as well as possible. This paper provides an evaluation of this methodology and defines its range of application as well as its limits.

The aim of anatomical models, on the other hand, is to simulate numerically all quantities potentially relevant for the evaluation of vibration behaviour, as well as to calculate those unknown quantities not accessible from experimentation, e.g., the loading of the lumbar spine.
The basis for these models is human anthropometry and physiology [2]. Multi-body systems and finite element models are utilised as mathematical models. Because of the complexity of the claim, the validation of anatomical models with the help of experiments on test persons is important. This paper gives an overview of various types of anatomy-based models, their range of application, and the current trends in this field.
Two types of hardware vibration dummies have been developed so far: Passive and active dummies. Both types of dummies aim to reproduce the driving-point impedance at the interface to the seat. Passive dummies consist of a system of masses, springs and dampers. They are based on phenomenological models. Active dummies additionally use an actuator to meet given response functions in a more flexible way.

Results

There is a broad variety of biodynamic models used to simulate human whole-body vibrations [3]. The use of these models requires a critical check of the biodynamic properties employed to describe the models, as well as how they were validated [4].This is most important for numerical models, but also valid for hardware dummies.
In order to accurately simulate motions and loads numerically, including the effects on health and comfort sensations of an individual exposed to vibration, a high level of research is essential. In particular, this necessitates the extension and systematisation of the experimental database needed for the validation of spatial vibration behaviour, and to what extent the dependence of the factors of posture, anthropometric properties, age, gender and potential pre-damage can be systematically calculated.
For anatomy-based models, there is an urgent need for research on the modelling of the lumbar spine, especially with regard to the development of damage models, the modelling of muscles, the influence of muscle activity, and finally the modelling of the inner organs and soft tissue involved in the man-seat interface.

Conclusion

Numerical biodynamic models are needed for any systematic analysis of the relationship between vibration exposure, health and comfort. But the range of their application must be carefully limited to the range in which they are validated. Numerical models and hardware dummies will help to support the development of technical systems for the reduction of vibration impact.

References

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