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Defining space models of arm reach envelopes for static forced postures

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Abstract. Forced postures are regarded as related to the location of a technical structure's touch points. The aim of this research study was to interpret the basic biomechanical criteria of the EN 1005-4 standard (also ISO/DIS 11226), defining standing posture categories as parameters of the corresponding arm reach envelopes. This form of data presentation makes direct application of these criteria possible in the design and evaluation of a technical structure. Forced static postures were simulated according to angle ranges of the standard for trunk bending and upper arm elevation. Arm reach of representatives of the Polish population was measured with a model consisting of modular elements movable perpendicularly to the frontal plane. The results formulated in the Cartesian system of co-ordinates were developed with Mechanical Desktop software and presented as spatial arm reach envelope models, and graphically, too. In practice it was possible to compare the location of touch points with reach envelopes to assess just the technical structure according to the assumed working posture categories as acceptable, conditionally acceptable or unacceptable.

Keywords: Static forced posture categories, spatial models of arm reach, assessments method

1. Introduction

Forced postures are among the most important factors of workers' discomfort and musculoskeletal load. Particularly adverse is the load resulting from maintaining forced static postures. Such standing postures can be found mostly when reaching contact points requires unnatural trunk bending and/or upper arm elevation. This should be controlled and eliminated already at the design stage.

Many authors described working postures and ways of assessing them, e.g. [1,2,8]. However they did not consider forced postures in relation to workspace and corresponding reach envelopes.

This study is based on assessment criteria for static postures, which can be found in the newly developed standard No. EN 1005-4 [3] (and also ISO/DIS 11226 [7]). They are formulated as acceptable, conditionally acceptable and unacceptable angle ranges for positions of body parts, maintained over a specific period. The use of those criteria in practice is a serious methodological, organizational and technical problem when creating design assumptions, assessing documentation and a prototype.

As a matter of fact it is a question of assessing the spatial structure of a technical object, with which a human relates in the work process. So, an attempt was undertaken to re-formulate the biomechanical

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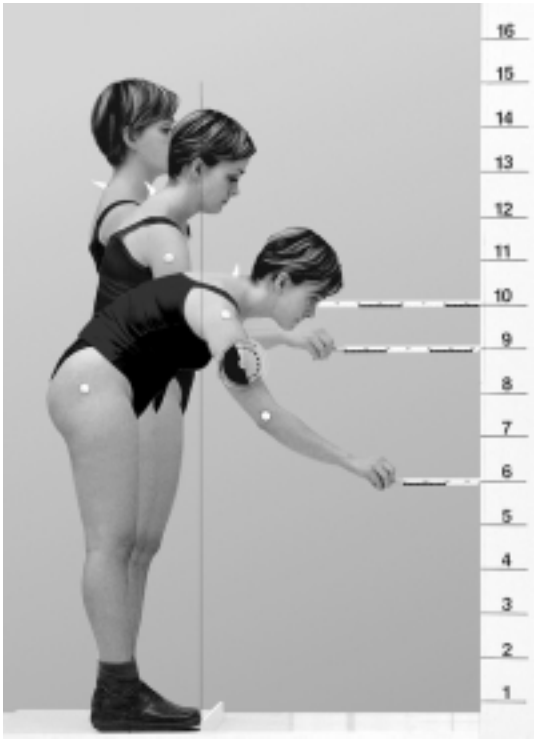

Fig. 1. The dependence of posture on the location of a touch point.

criteria that describe a forced posture categories into related arm reach parameters in the Cartesian coordinate system, appropriate for assessing a technical structure. Showing the relationship between the posture categories of the standard and corresponding arm reach envelopes is the essence of this study.

2. Method

This study assumed that there was a direct relationship between the location of touch points in the workspace and the category of forced working postures. There are opinions in the literature that this relationship is in principle repeatable for a given person and specific spatial conditions (see, e.g. [6]). It was also possible to assume that a technical structure could be assessed in posture categories when compared with corresponding arm reach envelopes. To study this relationship, these postures were simulated in laboratory conditions and direct measurements of reach envelopes were made (Fig. 1).

It has been assumed that the body being measured is in a standing posture, not stabilized in any special way, except for the monitored angles and the position of the feet. These simulated standing postures were established with special pendulum goniometers (Fig. 2), so trunk bending forward and upper arm elevation (solid angles) in boundary positions were monitored continuously.

The boundaries of arm reach in those positions were shaped using a special operational model equipped with modular elements movable perpendicularly to the frontal plane. In the measurements, the frontal plane (basis anterior, BA) was treated as a common reference plane for the human and the space structure of a technical object. The range of the movements of the elements was measured, with the results further processed.