

MUSCULOSKELETAL SHOULDER MODEL STRENGTH DEPENDS STRONGLY ON SEGMENT CONFIGURATION.

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BACKGROUND

The AnyBody Group at Aalborg University has developed an implementation of the Delft shoulder model (Van der Helm, 1994) in the AnyScript modeling language. The model has many possible applications, but the main motivation behind it is a desire to predict the discomfort of seated car drivers as a function of seat and package parameters in the early design phase of a vehicle. The initial experiments with the model reveal that its strength appears to be very sensitive to the mutual positions of segments in the model. This paper investigates that phenomenon further.

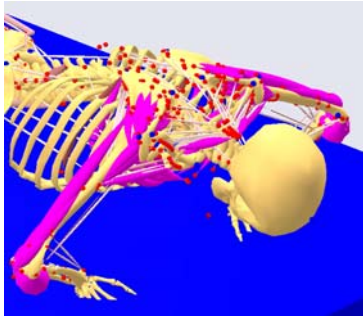


Figure 1: The AnyScript shoulder and upper limb model during a push-up exercise.

METHODS

A musculoskeletal model of the human thorax, shoulder and arm was developed in the AnyBody Modeling System (www.anybodytech.com) using its modeling language, AnyScript, and it was added to existing lower limb models. The muscle configuration and anthropometrical data of the shoulder model were based as closely as possible on the published Delft Shoulder Model, (Van der Helm et al. 1991, Veeger et al. 1991). The entire model including the lower extremities comprises 312 muscles of which 228 belong to the shoulders and arms.

The AnyBody Modeling System is an inverse dynamics system recruiting muscles based on a criterion that distributes forces over redundant muscles to minimize the maximum muscle activation. Several different muscle recruitment criteria are used in the

literature, but the min/max criterion is particularly interesting when comparing strengths of models because it represents the upper limit of strength the model can mechanically have. A model of a normal push-up exercise was used as the first crude numerical validation experiment. The background is that a push-up is expected to result in muscle activations in the vicinity of 100% of maximum voluntary contraction.

The AnyBody Modeling System can model force/length and force/velocity properties of muscles, but to eliminate other influences than the muscle and bone configuration, isometric conditions were presumed with all muscles operating at their optimum isometric strength.

RESULTS AND DISCUSSION

The initial experiments revealed muscle activities of more than 1000 percent, i.e. the model was more than ten times overloaded. Closer investigation revealed that this was due to the support forces running through the arms to the scapula, and the entire body being suspended from the scapula. The action angles of the muscles connecting the scapula to the thorax are strongly dependent on the relative position of the scapula, and by varying this position manually the activity level can be reduced to only slightly more than 100%.

This strong dependency is a challenge to the quality of musculoskeletal models of the shoulder complex, and it is necessary to devise methods for automatic adjustment of the kinematics of the internal degrees of freedom of the shoulder.

REFERENCES

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