The contribution of muscle forces to spinal loads

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Spinal vertebrae are subjected to a combination of loads from disks, facet joints, ligaments and active muscle forces. The latter are disregarded in in vitro tests but may contribute an important part of the load on the spine. Considering the complexity of the spinal muscle configuration, it is unlikely that any simplified external load will mimic the effect of the muscles in activities of daily living. Disregarding muscles when designing spinal implants might therefore lead to erroneous estimations of the forces carried by implanted structures.

This paper investigates computational estimation of muscle forces to a significant level of detail. A model comprising several hundred muscles [1,2] is presented and validated against experimentally measured disk pressures for a range of activities of daily living. Subsequently, the model is used to investigate the contribution of muscle forces in vertebral loads by simulating an in vitro test with and without muscles.

The individual muscle forces of the model cannot be validated, but their overall magnitude is given by dynamic equilibrium governed by the difference of moment arms between the external loads, including gravity, and the muscle forces. Thus, the difference in result depending in inclusion or exclusion of muscles documents that muscle forces play a significant role and should be considered when dimensioning spinal implants.

To the extent muscle forces can be estimated reliably, musculoskeletal simulation can be used to compute the loads on spinal implants for a variety of activities of daily living, thus providing improved criteria for spinal implant design.