# NEURAL NETWORK AND REGRESSION ESTIMATIONS OF SPINE LOADS AND MUSCLE FORCES IN LIFTING TASKS

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## Introduction

Proper prediction of trunk muscle forces and spine loads is essential to design prevention and rehabilitation programs. While models assuming single equivalent muscle are simple but inaccurate, detailed models are reliable but complex for practical applications. We aim to establish artificial neural networks (ANNs) that relate inputs of a detailed model to its outputs (compression/shear forces at L4-S1 levels and muscle forces) during static lifts. Relative performance of ANNs and regression equations [Arjmand et al, 2012] in mapping input-output relationships is also investigated.

## Method

Model inputs are lifted mass, its anterior (*Dx*) and right lateral (*Dy*) distances to the L5-S1 centre, handling technique (one- or two-handed), and trunk flexion angle relative to the upright posture. The associated pelvic and lumbar rotations are based on the literature. A number of levels for each input is taken and all 5760 combinations of the input levels are each inputted into the the finite element kinematics-driven (KD) model that predicts the outputs (spine loads and muscle forces) [Arjmand et al, 2012]. Adequate ANNs are developed to map the relationship between inputs and spine loads and 76 muscle forces, respectively. Back-propagation method is used to train the ANNs with 90% of the KD input-output dataset. Remaining 10% of dataset are used to test the generalization capability of the trained ANNs. ANN predictions are compared with those of regression equations developed here and earlier [Arjmand et al., 2012].

## Results

ANNs were more accurate in mapping input-output relationships (*RMSE*= 20.7 N for spinal loads and *RMSE*= 4.7 N for muscle forces) as compared to regression equations (*RMSE* = 120.4 N for spinal loads and *RMSE* = 43.2 N for muscle forces). Compared to the regression equations, the ANNs predictions for force in right longissimus thoracis pars thoracic (LGPT) and L5-S1 compression/shear loads as trunk flexed symmetrically forward from upright posture (no load in hands) better matched KD predictions (Figure 1a, b). This trend was also seen in asymmetric one-handed lift of 10 kg in upright posture (arms fully stretched) as the load shifted from lateral (*Dx*=0) to sagittal (*Dy*=0) position (Figure 1c).

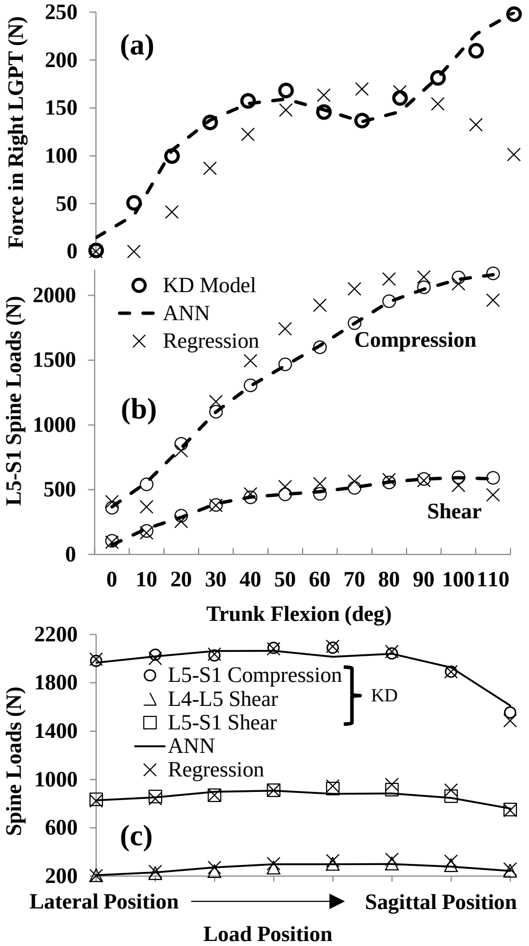


*Figure 1: Accuracy of ANN vs. regression models.*

## Discussion

Both mapping tools, when developed based on the data from a complex model, demonstrated accuracy and ease of use in estimating muscle forces and spine loads in symmetric and asymmetric lifts. Compared to the regression equations, the ANNs however mapped the input-output relationships more accurately.

## References

Arjmand et al., Clin Biomech, 27:53-44, 2012.