Corrigendum to "Identifying intrinsic and reflexive contributions to low-back stabilization" [J. Biomech. 46(8) (2013) 1440-1446]

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Corrigendum

Corrigendum to "Identifying intrinsic and reflexive contributions to low-back stabilization" [J. Biomech. 46(8) (2013) 1440–1446]

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In our paper lumbar stabilization was investigated by presenting the mechanical admittance and reflexive activity in the frequency domain and a neuromuscular model. In the original paper the EMG of the longissimus muscle was described as positive, where extensor muscles should have been defined as negative, resulting in a phase shift of -180° (Fig. 4; phase of the EMG-reflexes). This affected the modelling (Figs. 5–8 and Table 2 in the original paper). In contrast to the original paper, the modelling no longer supports the role of force feedback and attributes considerable resistance to the reflexes.

Additionally, a typographical error was found in the model structure (Fig. 3).

2.5. Parametric identification (Addition)

The trunk mass (m) was estimated for each individual subject using anthropometric methods (Clauser et al., 1969|6575), resulting in an average of 39.8 kg. In some cases the model became unstable, which was resolved by a penalty function for positive real Eigen values.

3.2. Identification of intrinsic and reflexive parameters (*Summary*)

The intrinsic model with MS feedback (2) was selected for further analysis, as it described the displacements ($VAF_x=90\%$) and the EMG measurements ($VAF_e=36\%$ over all frequencies and $50\% < 3.5$ Hz) rather well and the SEM values (average 40% of the subject-averaged parameter values) indicated a reliable estimate of the parameters (Table 2). All others models incorporating reflexes resulted in comparable VAF_x and in either only slightly improved VAF_e (models 3–6 and 8) or in improved VAF_e with poor SEM values (model 7). Considering the variation in gender and age of the subject group, parameter estimates (Fig. 7) were consistent over subjects.

3.4. Intrinsic and reflexive contributions (*Replacement*)

The reflexive contribution to low-back stabilization is illustrated simulating the admittance of the complete model (2) and removing (MS) reflexes (Fig. 8). Note that parameters of the model without MS were not re-estimated and do not represent the best

Table 2
Results of different model configurations: The variance accounted for (VAF) and percentage standard errors of the mean of the subject-averaged parameter values (% SEM) averaged over all subjects and parameters (mean($\pm$std)). The intrinsic model includes trunk inertia, intrinsic properties and contact dynamics. Feedback from the muscle spindles (MS), the vestibular organ (vest) and Golgi tendon organ (GTO) has been added as well as a head mass (head), an acceleration component from the muscle spindles (MS_{acc}), and separate time delays for the MS and GTO (τ_{MS} and τ_{GTO}).

Model options	VAF_x [%]		VAF_e [%]		% SEM
	Relax	*Resist*	*Relax*	*Resist*	
(1) Intrinsic	87.5 (7.3)	85.9 (7.1)	–	–	9
(2) Intrinsic+MS	89.5 (6.9)	90.6 (3.7)	34.9 (14.9)	36.9 (21.1)	40
(3) Intrinsic+MS+MS_{acc}	89.3 (7.4)	90.4 (4.2)	36.6 (13.3)	44.8 (08.5)	35
(4) Intrinsic+MS+vest	89.3 (7.4)	89.9 (4.2)	37.8 (12.6)	45.0 (09.8)	2154
(5) Intrinsic+MS+GTO	89.2 (7.3)	91.3 (3.4)	37.2 (13.9)	39.3 (21.0)	113
(6) Intrinsic+MS+GTO (τ_{MS} and τ_{GTO})	88.9 (7.1)	91.3 (3.5)	38.0 (13.9)	39.1 (20.6)	58
(7) Intrinsic+MS+GTO+vest	89.4 (7.3)	91.4 (3.7)	41.8 (12.6)	48.9 (07.2)	106
(8) Intrinsic+MS+GTO+head	89.3 (7.1)	91.2 (3.4)	34.3 (27.1)	44.0 (18.2)	40

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0021-9290/

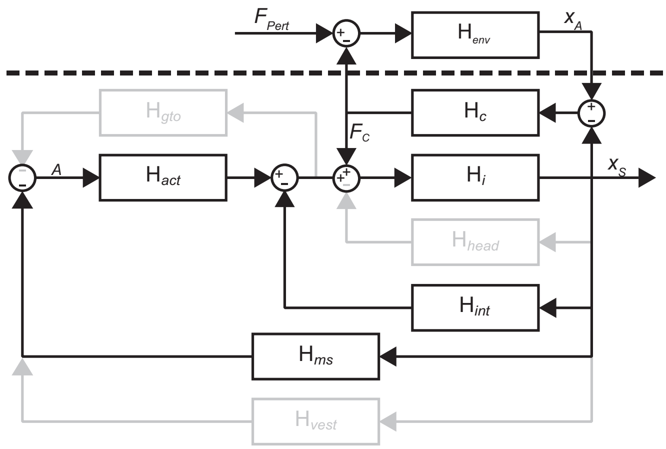

Fig. 3. The model structure.

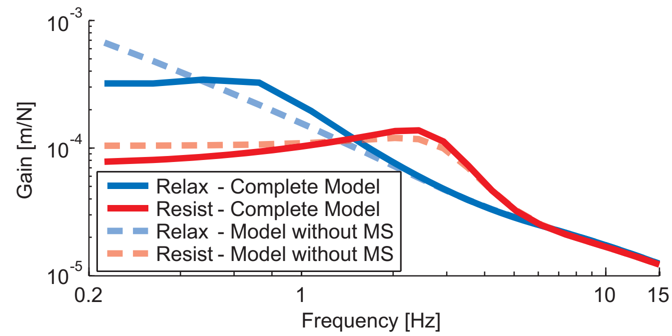

Fig. 8. Effect of MS feedback illustrated using NMC models of a typical subject during a relax (blue) and resist (red) task visualised by the admittance of the complete models including MS feedback (solid) and this model without MS feedback (dashed).

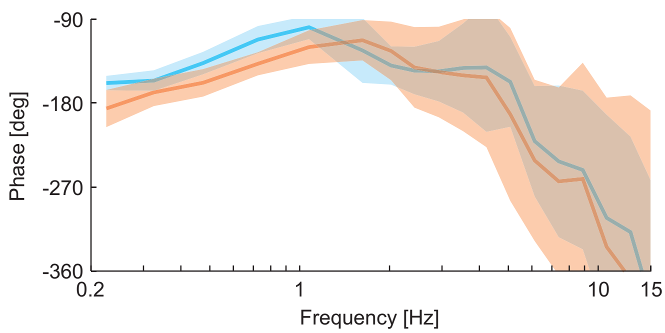

Fig. 4. (mid right) Phase of the EMG-reflexes.

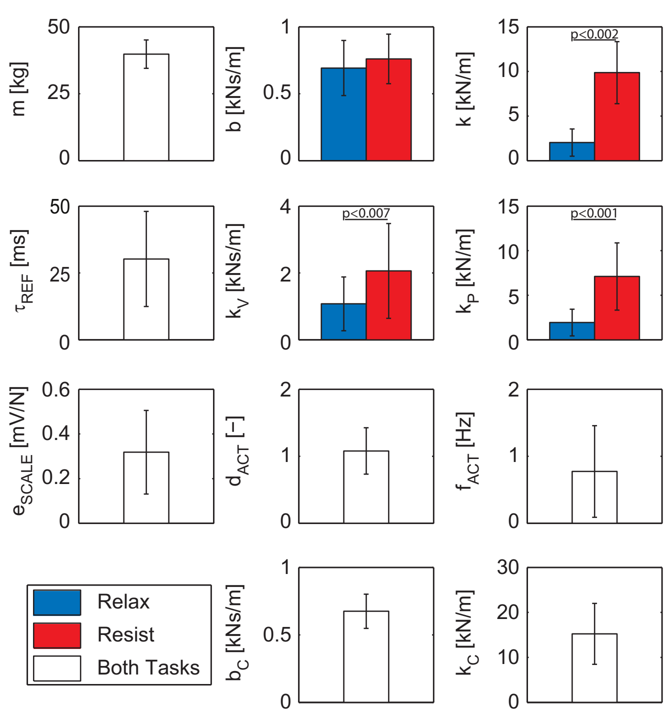

Fig. 7. Subject-averaged estimated parameters. The error bars represent the standard deviations. The parameters modulated due to task instruction have different estimated values for the relax task (red) and the resist task (blue) and the *p*-values show the significant differences.

possible fit. Differences were primarily observed at the lower frequencies, where the MS reflexes reduced the admittance. The reflexive contribution led to a 25% and 52% reduced admittance at the lowest tested frequency during the resist and relax task, respectively, indicating the intrinsic stiffness to have a larger relative contribution during the resist task.

4. Discussion (*Replacement of 4th and 5th paragraph*)

The estimated trunk mass (39.9 kg) and intrinsic stiffness in the relax task (2.0 kN/m) were comparable with values in Moorhouse and Granata (2005), while the estimated intrinsic damping (692 Ns/m) during the relax task was higher, possibly because the hand-position on the head in the current experimental setup results in higher stabilization demands. The estimated reflex time delay of 30.2 ms is within the expected (short-latency) range (Goodworth and Peterka, 2009). For the resist task, increased intrinsic stiffness (from 2.0 to 9.9 kN/m) was found similar to Gardner-Morse and Stokes (2001) and Granata and Rogers (2007), where increased muscle activation led to increased intrinsic stiffness. Also the proprioceptive feedback gains modulated with task instruction. Both position and velocity-referenced information seems to be more important for a resist task, because the model showed a strong increase in MS position and velocity feedback. The model variations in Fig. 8 indicate that reflexes increase the overall resistance in both the resist and the relax task. During the resist task, the model attributes a substantial resistance to the intrinsic stiffness with respect to the MS position feedback. During the relax task, the contribution of the intrinsic stiffness and reflexive position feedback is approximately equal, indicating that the energy-consuming intrinsic stiffness becomes less dominant during natural posture maintenance.

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