COMPARISON OF PREDICTED SPINE LOADS BY FOUR LIFTING ANALYSIS TOOLS AND A REGRESSION MODEL

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Introduction

Estimates of loads on spine during occupational tasks remain as elusive as ever despite need for the design of safer workplace and injury prevention programs. Several quantitative lifting analysis tools for spine loads are currently available in ergonomics though evaluation and comparison of their estimations is missing. We aim hence to compare predictions of five tools when applied to identical lifting tasks. Beside critical assessment of their respective underlying assumptions, this should help provide much-needed guidance to ergonomists.

Method

Five tools (3DSSPP®, AnyBody®, HCBCF of the University of Utah [Merryweather, 2009], EMG-based McGill's polynomial [McGill, 1996], and our regression models based on an anatomically detailed multi-joint finite element model [Arjmand, 2012]) are used to simulate seven tasks for which *in vivo* intradiscal pressure (IDP) data are available: 1) relax upright posture, 2-3) lifting 19.8 kg once at 30 cm and then 60 cm anterior to the L5-S1 in upright posture, 4) flexing forward by 50°, 5) flexing forward by 70° while holding 19.8 kg, 6) flexing forward by 110°, and 7) asymmetric one-handed lift of 19.8 kg on the left side in the upright posture. Body weight of 70 kg and height of 174 cm similar to the subject in the IDP measurements [Wilke, 2001] are assumed.

Results

Predicted spine loads (N) by different tools are in Table 1. Comparison of predicted L4-L5 IDP values with *in vivo* data is in Figure 1.

Discussion

Excluding the regression models, all tools use equilibrium at one single joint and neglect translational DOFs and their corresponding equilibrium equations. Utah's and L5-S1 3DSSPP models include only one extensor muscle and ignore passive spine resistance. L4-L5 3DSSPP model has also limited number of muscles. 3DSSPP predicted for the asymmetric task the extreme compression loads being the lowest at the L5-S1 level (413 N) while largest at the L4-L5 (2180 N). McGill's model predicted the greatest L4-L5 compression for the lightest task (task 1, 1064 N). Differences between the tools reached ~40% and 35% for L4-L5 and L5-S1 compression, respectively. Regression models estimated relatively higher L5-S1 shear. Utah's tool only model symmetric tasks. AnyBody® failed to model deep flexion tasks. McGill' and Utah's models do not provide shear forces.

3DSSPP®	**L4-L5**	C	302	1299	2285	1665	2767	1340	2217
		S	139	208	147	263	525	324	357
	L5-S1	C	365	1393	2382	1824	3070	1554	444
		S	220	347	342	291	512	329	342
AnyBody®	**L4-L5**	C	391	1317	2241	1569	3208	-	1645
		S	33	127	248	183	395	-	120
	L5-S1	C	440	1411	2353	1681	3373	-	1820
		S	50	242	454	327	713	-	192
Utah	**L5-S1**	C	494	1494	2339	1992	3630	-	-
McGill	**L4-L5**	C	1064	1235	2058	1380	2763	1622	1410
Regression Models	**L4-L5**	C	396	1327	2617	1711	3307	1875	1628
		S	13	242	555	135	357	153	145
	L5-S1	C	420	1178	2405	1743	3517	1963	1588
		S	139	705	1426	524	1035	460	677
Task			**1**	**2**	**3**	**4**	**5**	**6**	**7**

Table 1: Spine loads (C: compression, S: shear)

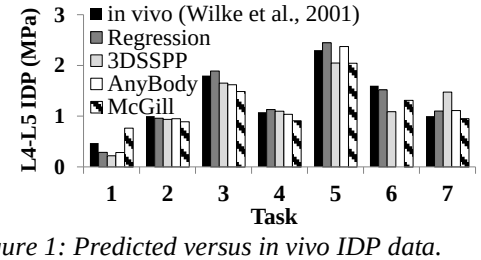

Figure 1: Predicted versus in vivo IDP data.

References

Arjmand et al., Clin Biomech, 27:53-44, 2012.
McGill et al., Ergonomics, 39:1107-18, 1996.
Merryweather et al., Work, 34:263-72, 2009.
Wilke et al., Clin Biomech, 16:S111-26, 2001.