

Activation characteristics of trunk muscles during whole body tilt with unsupported trunk



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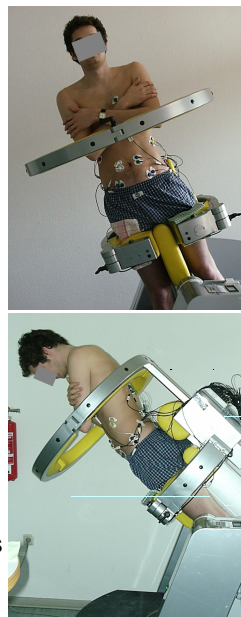
Background

Proper muscle coordination is an essential prerequisite for vertebral stability. Training programmes for single muscle activation exist, but graded and therefore metered coordination training for more than one trunk muscle is not available up to now.

Method

- 31 healthy volunteers (15 male and 16 female subjects)
- Load on trunk was applied by tilting the device while subjects remained in axial neutral position with unsupported trunk (see figure)
- Tilting angles in forward and backward directions: 5°, 10°, 20°, 30°, 45°, 60°, 90°
- Right and left sided tilt angles: 5°, 10°, 20°, 30°, 45°
- Surface EMG (SEMG) of five trunk muscles was measured during static conditions
- Root mean square (rms) values were calculated and normalised according to the maximum level of all performed tasks

muscle	tilt direction	differences					
		5° to no tilt	10° to 5°	20° to 10°	30° to 20°	45° to 30°	60° to 45°
ra left	backwards	**	**	**	**	**	*
	right	**	**	**	**	**	**
oi left	backwards	n.s.	n.s.	**	**	**	**
	right	**	**	**	**	**	**
oe left	backwards	**	**	**	**	**	**
	right	**	**	**	**	**	**
mf left	forward	**	**	**	**	**	**
	right	**	*	**	**	**	**
es left	forward	**	**	**	**	**	*
	right	*	n.s.	**	**	**	**
ra right	backwards	**	**	**	**	**	*
	left	**	*	**	**	**	**
oi right	backwards	**	n.s.	**	**	**	**
	left	*	n.s.	**	**	**	**
oe right	backwards	**	**	**	**	**	**
	left	**	**	**	**	**	**
mf right	forward	**	**	**	**	**	**
	left	n.s.	n.s.	**	**	**	**
es right	forward	**	**	**	**	**	*
	left	n.s.	n.s.	**	**	**	**



muscle	direction combination	5°	10°	20°	30°	45°
ra left	backwards vs. right	**	**	**	**	**
ra right	backwards vs. left	*	**	**	**	**
oi left	backwards vs. right	**	**	n.s.	n.s.	n.s.
oi right	backwards vs. left	**	**	n.s.	n.s.	*
oe left	backwards vs. right	**	**	**	**	**
oe right	backwards vs. left	**	**	**	**	**
mf left	forward vs. right	**	**	**	**	**
mf right	forward vs. left	**	**	**	**	**
es left	forward vs. right	**	**	**	**	**
es right	forward vs. left	**	**	**	**	**

Statistics for identification of graded activation for the applied tilt angles (above) and differences in activation for corresponding angles (left)

Aim

To investigate the activation patterns of trunk muscles in a new training device for trunk muscle coordination and strengthening.

muscle	tilt direction	5° 10° 20° 30° 45° 60° 90°																	
		male	female	U-Test	male	female	U-Test	male	female	U-Test	male	female	U-Test	male	female	U-Test	male	female	U-Test
ra left	backwards	2.1 (2.8/1.4)	8.2 (14.6/5)	**	2.4 (5/1)	19.5 (28.9/6)	**	15.6 (33.5/7)	50.0 (95.7/34.5)	**	39.9 (48.1/27.6)	111.7 (167.5/61.7)	**	161.8 (193.6/103.8)	162.3 (265.0/130.8)	n.s.	238.4 (304.5/142.8)	195.4 (340.2/109.0)	n.s.
	right	2.4 (2.8/1.4)	2.8 (3.7/2.4)	**	2.3 (2.8/1.3)	3.8 (5.4/3.3)	**	3.4 (4.2/2.0)	8.6 (12.1/6.4)	**	5.4 (7.6/3.3)	13.4 (19.5/11.5)	**	20.1 (42.3/8.4)	28.8 (37.2/6)	n.s.			
	U-Test	n.s.	**	**	n.s.	**	**	n.s.	**	**	n.s.	**	**	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
oi left	backwards	11.8 (19.3/4.9)	14.7 (21.5/10.6)	**	9.0 (12.6/5.1)	23.9 (33.1/5.5)	**	18.2 (22.5/16.1)	51.4 (87.2/43.1)	**	37.3 (46.8/29.4)	83.7 (119.7/64.7)	**	99.0 (124.5/69.2)	133.6 (155.7/128.3)	n.s.	171.3 (200.2/131.2)	189.3 (223.8/133.4)	n.s.
	right	11.6 (30.7/9.4)	18.5 (31.7/11.3)	**	15.8 (38.0/12.1)	26.5 (42.6/15.2)	**	25.8 (55.5/20.3)	33.1 (72.5/28.2)	n.s.	42.1 (74.9/26.9)	55.3 (91.8/32.9)	n.s.	65.8 (121.8/43)	96.4 (122.7/67.5)	n.s.			
	U-Test	n.s.	**	**	n.s.	**	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
oe left	backwards	4.9 (7.5/3.6)	18.3 (26.2/11.2)	**	11.3 (15.5/8.9)	26.1 (36.7/22.9)	**	27.2 (32.2/23.8)	47.5 (70.5/30.5)	**	39.1 (48.3/32.1)	69.4 (96.1/47.4)	**	69.1 (102.7/60.4)	97.5 (130.2/85.2)	n.s.	129.6 (158.9/109.4)	128.5 (193.1/98.8)	n.s.
	right	4.2 (5.6/2.8)	9.3 (13.2/7.1)	*	5.8 (7.2/5.2)	14.6 (20.2/10.6)	**	11.8 (14.6/8.2)	25.2 (34.5/19.6)	**	17.5 (23.6/12.9)	32.5 (46.6/27.7)	**	33.9 (49.3/19.1)	52.5 (67.4/39.7)	n.s.			
	U-Test	n.s.	**	**	n.s.	**	n.s.	n.s.	**	**	n.s.	**	**	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
mf left	forward	22.1 (31.0/20.9)	18.1 (22.6/15.6)	n.s.	40.5 (44.8/28.7)	28.2 (34.4/24.2)	n.s.	54.3 (65.0/43.7)	52.4 (83.3/34.5)	n.s.	65.6 (77.9/58.1)	63.7 (99.9/48.4)	n.s.	88.7 (96.7/2.5)	98.9 (106.7/95.5)	n.s.	102.4 (112.3/89.0)	83.9 (99.1/69.1)	n.s.
	right	19.1 (20.8/12.3)	15.4 (18.4/11.6)	n.s.	17.3 (22.6/15.2)	17.5 (19.7/12.4)	n.s.	23.1 (27.9/17.9)	26.8 (28.9/20.8)	n.s.	31.3 (39.1/27.8)	28.2 (40.9/25.2)	n.s.	53.5 (59.5/43)	46.8 (61.3/38.5)	n.s.			
	U-Test	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
es left	forward	27.7 (34.0/24.0)	24.8 (28.5/19.6)	n.s.	34.3 (48.7/28.9)	32.1 (37.7/26.3)	n.s.	48.6 (64.2/37.0)	41.3 (54.3/36.7)	n.s.	63.3 (76.7/44.0)	60.4 (67.4/48.8)	n.s.	81.1 (96.5/53.8)	87.4 (109.2/67.5)	n.s.	106.1 (131.5/73.6)	95.7 (103.9/72.0)	n.s.
	right	17.4 (23.0/13.0)	11.9 (16.9/7.3)	*	16.5 (21.6/14.3)	10.0 (16.7/7.4)	*	18.1 (24.4/14.3)	13.9 (23.3/10.3)	n.s.	22.2 (32.9/17.2)	18.7 (27.5/14.4)	n.s.	37.5 (45.7/23.6)	36.1 (41.1/27)	n.s.			
	U-Test	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

SEMG amplitudes of left sided muscles (median, upper/lower quartiles). Differences between both sexes were tested

Results

- Maximum amplitude levels were reached during forward and backward tilt directions, respectively
- amplitude dynamics for the applied tilt angles do differ between men and women
 - men reached 50% of maximum amplitude at 45° angle for abdominal muscles and at 30° for their back muscles
 - women reached 50% of maximum amplitude at 45° angle for the rectus muscle, all other muscles reached 50% at 30° tilt angle during forward and backward tilt angles, respectively
 - women showed higher SEMG amplitudes of their abdominal muscles during backward tilt direction up to tilt angles of 30°, men showed higher SEMG amplitudes of their multifidus muscle during forward tilt up to tilt angles of 60°
- back and forward tilt angles elicited more activity than the corresponding sideward tilt angles did, except internal oblique muscle which was characterised by comparable amplitudes during backwards and left/right directions

Discussion/Conclusions

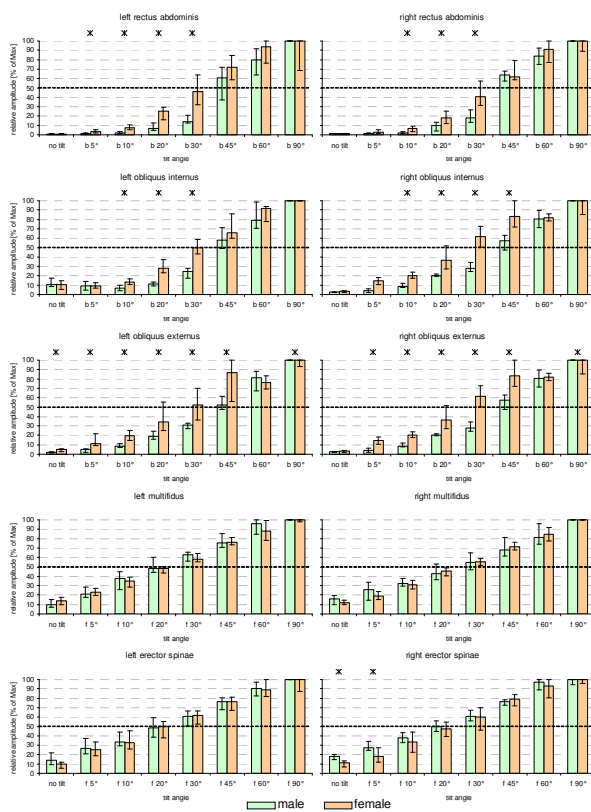
A graded and therefore highly coordinative activation of relevant trunk muscles is possible by using the device

Sideward tilt angles do not evoke equal strain levels as back and forward angles do, except for internal oblique muscle

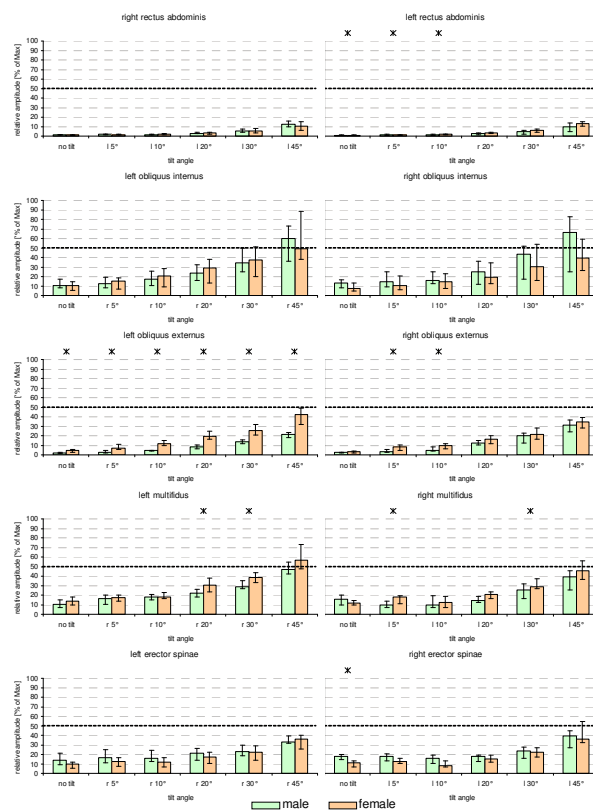
Up to tilt angles of 30° women are characterised by higher strain levels of their abdominal muscles if compared to men

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Relative SEMG amplitudes during forward and backward tilt directions, respectively. Gender differences are indicated by asterisks. (median, upper and lower quartiles)



Relative SEMG amplitudes during right-sided and left-sided tilt directions, respectively. Gender differences are indicated by asterisks. (median, upper and lower quartiles)