Muscle activity, ground reaction forces and pointing performance during postural control tasks in healthy adults

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Abstract

To investigate the muscle coordination during postural control, we recorded muscle activity and postural dynamics in healthy human adults. Fourteen participants performed postural tasks in which postural stability and pointing behaviour was varied. The data set contains electromyography of 36 muscles distributed across the body and ground reaction forces recorded during postural control tasks. A full factorial design was used. Stability was either not challenged or challenged in the anterior-posterior or medial-lateral direction. In addition, participants were asked to either relax their arms or to perform an unimanual or a bimanual pointing task. In the pointing task, participants held a laser pointer and pointed it on a target in front of them. Pointing performance was recorded using a video recording of the laser beam on the target area.

General

Fourteen healthy participants (seven male, age 25±8 years, ten right-handed, BMI below 25) without any neurological, motor disorder or diabetes mellitus were included in this study. The experiments were approved by the Ethics Committee Human Movement Sciences of the *Vrije Universiteit* Amsterdam (reference ECB 2014-78) and performed in full compliance with the Declaration of Helsinki. Participants were written and verbally informed about procedures and signed an informed consent prior to participation. Table 1 contains all the participant information.

Table 1. Information participants

subject	gender	age (years)	handedness	comments
1	female	24.37	right	
2	male	20.83	right	
3	male	24.42	right	one missing trial
4	female	25.25	right	one missing trial
5	female	22.78	right	one missing trial
6	male	21.52	right	
7	female	25.22	left	
8	female	19.76	left	
9	female	23.59	right	
10	male	22.38	left	
11	male	53.79	right	
12	male	26.03	right	
13	female	27.55	left	
14	male	21.64	right	

Muscle activity and force plate data was measured while participants were instructed to stand still with their feet aligned with their hip joints and their knees ten degrees flexed. The participants had to keep their centre of pressure within the base of support and were barefoot. Postural stability and pointing were experimentally manipulated.

Postural stability was manipulated using a balance board and varied between three conditions. In the normal stability condition the participants were standing on a block (height 13.5 cm) on

the force platform. In the anterior-posterior and medial-lateral conditions participants were standing on a balance board (height 14 cm) placed on the force platform. This balance board had one degree of freedom which allowed movement either in the anterior-posterior or medial-lateral direction, respectively. Before the experiment, participants were familiarised with the balance board in both directions for 30s.

Pointing was varied between three conditions: participants did not point, pointed unimanually with the dominant arm (based on their hand of preference) or bimanually on a target with a laser pointer. The target was a white square of 25 cm^2 surrounded by a bold black line that was fixed on a plane surface located at a distance of 2.25m from the participant parallel to the transversal axis of the body at the height of the acromion of the participant. In the no pointing condition, the participant focussed with their eyes on the target with the arms along the body. In uni- and bimanual conditions, participants held the laser pointer and pointed on the target with the shoulder(s) in an anteflexion position of 90°, the elbow(s) 10° flexed and the wrist(s) 90° pronated. In the bimanual task the participants held the laser with their dominant hand enclosed by the other non-dominant hand (isosceles stance). Participants had to maintain their balance during all conditions and to point on the target in the uni- and bimanual conditions.

The experiment consisted of nine (3×3) experimental conditions (Table 2). Duration of a trial was 30s; every condition was repeated six times. Trials were grouped in blocks of 2×9 trials; every block was repeated three times. After each trial, there were 30s rest and after each block there was a 3-minute break during which participants sat down. The order of conditions within blocks was randomized across participants.

Table 2. Conditions

stability \ pointing	no	unimanual	bimanual
normal standing	1	2	3
anterior-posterior instability	4	5	6
medial-lateral instability	7	8	9

Filenames
The filenames differentia between electromyography, force plate and video data by starting with either *EMG*, *FP* or *VID*, respectively. Names are followed by the subject (*S*), condition (*C*) and trial (*T*), respectively, e.g., EMG_S4C9T2.csv for the EMG of subject 4, condition 9 and trial 2.

Files
EMG: Files contain a matrix with the time series of the muscle activity in microvolt. The first column consists of the time points of every sample in seconds; the first row contains the names of the muscles measured. Data were recorded using a bipolar montage with three 16-channel Porti Systems (TMSi, 2 kHz sampling rate) and online high-pass filtered at 5 Hz. See Table 3 for the abbreviations of the 18 muscles that were recorded bilaterally. After an additional underscore, *d* or *nd* indicate whether the muscle was recorded on the dominant or non-dominant side, respectively.

Table 3. List of muscles

	muscle	abbreviation		muscle	abbreviation
1.	tibialis anterior	TA	10.	sternocleidomastoideus	SMA
2.	gastrocnemius medialis	GM	11.	longissimus	LO
3.	soleus	SOL	12.	latissimus dorsi	LD
4.	rectus femoris	RF	13.	trapezius	TZ
5.	biceps femoris	BF	14.	deltoid	D
6.	vastus lateralis	VL	15.	biceps brachii	BB
7.	adductor longus	AL	16.	triceps brachii	TRB
8.	external oblique	EO	17.	extensor digitorum	ED
9.	pectoralis major	PMA	18.	flexor digitorum superficialis	FDS

FP: Files contain a matrix with the time series of the different transducers in the three (*x*, *y*, and *z*) directions in Volt. The first column consists of the time points of each sample in seconds; first row contains the names of the different channels which were measured. Data were collected with a Kistler force platform (9281B, 0.12×0.20m) and sampled at 200 Hz. The distance between feet and force plate sensors was 0.205m in the normal stability conditions and 0.195m in all instability conditions.

VID: Video data were sampled at 29.97 Hz. There were extra visual triggers during the trials which are shown as brief light flashes outside the target area. Video data of trials S5C6T3, S5C6T4, S5C8T3, C5C8T4, S7C5T6, S9C3T3, S9C3T4, and S9C6T3 are missing.

Synchronisation
All modalities were synchronised using an external trigger. EMG, FP and video data can be aligned using the time in the first column of the files.