Surface electromyographic recordings of the biceps and triceps brachii for various postures, motion velocities and load conditions.

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— Please note: This is a revised version as the dataset contained an error in the previous version. In this version, the error in the dataset has been corrected. The old version is available here for reference: http://doi.org/10.57720/1956 —

The experimental data published in this dataset correspond to surface electromyographic recordings of the *biceps* and *triceps* muscles, as well as the elbow joint angle of several human subjects during the performance of various arm exercises under varying load situations. The data were originally recorded for the purpose of optimizing a musculoskeletal model of the upper arm with a focus on elbow movement in 2018 and 2019 as part of a research project at Bielefeld University of Applied Sciences, Germany. In the context of this publication, the data are made available to the scientific community.

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Subjects and Exercises

Surface electromyography (sEMG) data of the *biceps brachii* (*short head* and *long head*) and *triceps brachii* (*long head* and *lateral head*) and the corresponding elbow joint angle θ was acquired for $n = 31$ subjects (25 male, 3 female and 3 in none of these categories; see table 1) while the subjects were performing different elbow movement sequences with their dominant arm/hand (29 right-handed and 2 left-handed). All subjects were healthy and did not have any prior neuronal diseases when the experiments were performed. The movement sequences consisted of three different arm exercises with each at three different

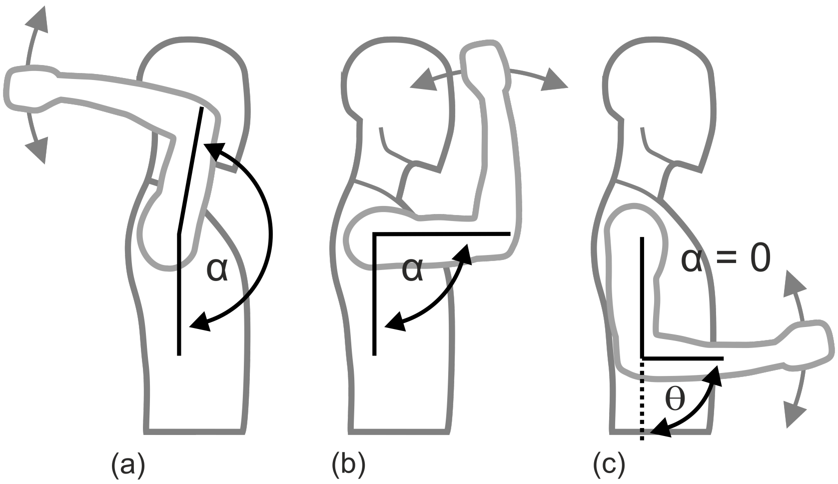

Figure 1: **Arm postures within the experimental conditions**. Upper arm angle α corresponding to (a) *upper curls* ($\alpha \approx 180°$), (b) *mid curls* ($\alpha = 90°$) and (c) *lower curls* ($\alpha = 0°$).The elbow joint angle θ is determined in relation to the upper arm.

loads and at two different *velocities*, resulting in a total of 18 experimental conditions (see table 2). The three different upper arm exercises performed were *upper curls*, *mid curls* and *lower curls* and are referred to as *postures* in the following (see fig. 1 for reference). During a) *upper curls* the upper arm was held vertically pointing upwards (fig. 1a), during b) *mid curls* the upper arm was held horizontally pointing forwards (fig. 1b) and during c) *lower curls* subjects were instructed to hold the upper arm vertically pointing downwards (fig. 1c). Subjects were asked to perform each exercise by cyclically moving the lower arm in a sinusoidal manner using a metronome as a visual and auditory reference. Each exercise was repeated at two different frequencies, referred to as *slow* ($0.25\,Hz$) and *fast* ($0.5\,Hz$) *velocity.* Again, each posture/velocity combination was performed with different additional *loads*, namely $0\,kg$, $2\,kg$ and $4\,kg$. In case of the $2\,kg$ and $4\,kg$ loads the subject held a weight while maintaining the neutral forearm position. Exercise lengths varied due to muscle fatigue of individual subjects. Due to this circumstance, the recorded data used varies in length per experimental condition and subject.

Determination of maximum isometric muscle force

The system used for determining the maximum isometric muscle forces generated at the center of the subject's hand during *flexion* and *extension* of the forearm via *maximum isometric muscle contraction* (MVC) measurements consisted of an adjustable inelastic strap connected to a piezoelectric force transducer (9366CC, Kistler Instrumente GmbH, Sindelfingen, Germany). To determine the combined maximum isometric muscle force of the *biceps* heads F^{flex}_{max} during *flexion* of the lower arm each subject was instructed to hold the dominant lower arm in the horizontal direction grabbing the strap via a string loop with the hand oriented with the thumb pointing upwards while standing straight ($\alpha = 0\,°$, $\Theta = 90\,°$). The subjects were then instructed to pull the string as strong as they could for a time interval of $\Delta t = 5\,s$ while the force generated at the force transducer was recorded with a sample rate of $1\,kHz$ using a USB-based A/D-converter card (NI9215, National Instruments corp., Austin, Texas, USA). To ensure that the subject only pulled via the elbow joint each subject was instructed to minimize shoulder movement while pulling at the strap. The maximum force (F^{flex}_{max}) applied during the time interval Δt was saved.

To determine the maximum isometric muscle force of the *triceps* heads F^{ext}_{max} during *extension* of the lower arm the subjects where instructed to push as strong as they could with the bottom of the dominant hand placed on the force transducer for $\Delta t = 5\,s$ while the force F^{ext}_{hand} applied during the time interval Δt was recorded. Here, also subjects were instructed to position the forearm horizontally ($\alpha = 0\,°$, $\Theta = 90\,°$) and apply force only via the elbow joint and not by e.g. pressing with the upper body.

Recording of sEMG data

Wireless EMG sensors (Delsys Trigno, Delsys, Inc., Boston, MA, USA) were used to record muscle activity of each of the two heads (*short* and *long*) of the *biceps brachii* (*bic*) and two of the three heads (*long* and *lateral*) of the *triceps brachii* (*tric*), both involved in the actuation of the lower arm, with a sample rate of $1111\,Hz$ while subjects were performing exercise repetitions. Before placement of the sensors, the skin was cleaned using isopropanol alcohol and the innervation zones of the respective muscles where marked via pen and tape roller according to [1] in order to determine the adequate positioning of the sensors. After the preparation of the skin and the determination of the positional placement, the sEMG sensors were fixed with double-sided adhesive tape on the skin of the subjects. The interface between skin and electrodes was evaluated via instructing the subjects to separately contract the flexors and extensors of the upper arm and subsequent visual inspection of the signal quality.

Measurement of the elbow joint angle

A passive measurement orthosis was used to record the *elbow joint angle* θ while the subjects were performing different motion sequences (fig. 2). The measurement orthosis was custom designed and 3D-printed inhouse from polylactic acid (PLA) plastic. The mounting points and the overall length of the orthesis were customizable to allow the fitting to different arm geometries. The elbow angle is determined using a 10-bit magnetic rotary position encoder (AS5043, ams AG, Premstaetten, Austria) which was aligned to the rotary axis of the elbow joint of the subject. The analog output of the rotary encoder was fed into a Trigno Analog Adapter (Delsys, Inc., Boston, MA, USA) to allow for synchronous recording of the elbow joint angle θ and the sEMG data with a sample rate of $1925.9\,Hz$.

Figure 2: **Passive measurement orthesis and sEMG sensors used for simultaneous recording of elbow joint angle and muscle activation**. The measurement orthosis is mounted to the arm using flexible straps. The mounting points and the overall length of the orthosis is customizable to fit different arm geometries. The sEMG sensors are placed onto the *long* head and *short* head of the *biceps* and onto the *long* and the *lateral* head of the *triceps*. The wrist rotation is in neutral position.

Ethics statement

The study was conducted according to the ethical guidelines of the German Society for Psychology (DGPs) and the German Psychologists Association (BdP), and approved by the Ethics Committee of the University of Bielefeld (EUB 2017-156 02.08.2017). Informed consent was obtained from all subjects involved in the study.

Appendix

Table 1: Overview over all subjects. Age is given in whole years. All information is based on information given by the individual subjects. Maxima are marked in bold and minima in bold and italic.

	age	sex	height in m	weight in kg
subject_20	23	female	1.64	68
subject_21	25	male	1.76	75
subject_22	25	male	1.90	85
subject_24	24	male	1.83	60
subject_25	25	-	1.93	85
subject_26	25	male	1.80	65
subject_28	22	male	1.83	73
subject_29	26	male	1.76	80
subject_30	25	male	1.90	**130**
subject_31	26	-	1.77	67
subject_32	29	male	1.78	110
subject_33	25	male	1.87	90
subject_34	23	male	1.75	63
subject_36	26	female	1.75	67
subject_37	29	male	1.84	70
subject_38	24	male	1.80	75
subject_39	24	male	1.86	82
subject_40	25	male	1.82	68
subject_41	23	male	1.67	69
subject_42	23	male	1.87	81
subject_43	***22***	male	1.76	58
subject_44	25	male	1.86	85
subject_45	**34**	male	1.90	90
subject_46	27	-	**1.96**	105
subject_47	24	male	1.91	86
subject_48	28	male	1.86	98
subject_49	***22***	male	1.89	85
subject_50	25	male	1.85	70
subject_51	24	male	1.94	79
subject_52	32	male	1.90	74
subject_53	23	female	***1.60***	***47.0***
mean	25.26	-	1.82	78.71
standard deviation	2.71	-	0.09	16.27

Table 2: Listing of all *experimental conditions* per subject.

	posture		*velocity*		*load*		
upper curls	*mid curls*	*lower curls*	*fast*	*slow*	$0\,kg$	$2\,kg$	$4\,kg$
x	-	-	x	-	x	-	-
x	-	-	x	-	-	x	-
x	-	-	x	-	-	-	x
x	-	-	-	x	x	-	-
x	-	-	-	x	-	x	-
x	-	-	-	x	-	-	x
-	x	-	x	-	x	-	-
-	x	-	x	-	-	x	-
-	x	-	x	-	-	-	x
-	x	-	-	x	x	-	-
-	x	-	-	x	-	x	-
-	x	-	-	x	-	-	x
-	-	x	x	-	x	-	-
-	-	x	x	-	-	x	-
-	-	x	x	-	-	-	x
-	-	x	-	x	x	-	-
-	-	x	-	x	-	x	-
-	-	x	-	x	-	-	x

References

[1] Marco Barbero, Roberto Merletti, and Alberto Rainoldi. *Atlas of muscle innervation zones: understanding surface electromyography and its applications*. Springer-Verlag Italia, Milan, Italy, 2012. ISBN: 9788847024625.