DPValid collection

General information

Data Set Title: "DPValid collection".

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Dataset description

The DPValid dataset is composed of (anonymized) raw and processed data, including surface electromyography (sEMG) and dynamometry data collected on 20 healthy adults (HA) during a maximum voluntary isometric contraction test (MVIC), 10 females and 10 males.

For each subject, the following data will be made available:

- Dynamometry data – i.e., raw and filtered torques profiles acquired while the subjects performed maximal voluntary isometric contractions, both in extension (n = 3) and flexion (n = 3) with the knee flexed at 75° and 90°. In addition, the maximum torques values are also provided.
- Electromyography data – i.e., raw and filtered EMG data (including the normalised linear envelopes of the signals) recorded from 8 muscles (dominant and tested leg: biceps femoris, semitendinosus, rectus femoris, vastus medialis, vastus lateralis and lateral gastrocnemius; contralateral leg: vastus lateralis and biceps femoris) while the subjects performed the MVIC test.
- Muscle volume reconstructions – 3D segmentations of the major muscles of the thighs (n = 13 per side). The list includes the flexor and extensor muscles of hip and knee joints. More specifically: biceps femoris caput breve, biceps femoris caput longum, gracilis, iliacus, psoas, rectus femoris, sartorius, semimembranosus, semitendinosus, tensor fasciae latae, vastus intermedius, vastus lateralis, vastus medialis.

In addition, the demographics of all participants is reported in a separate CSV file.

Clinical study information

All the data were collected at the Rizzoli Orthopaedic Institute (IOR). The associated clinical study was approved by the local Ethical Committee (CE AVEC: 216/2020/Sper/IOR) and registered on the Clinical Trials registry (ID: NCT05091502). All subjects volunteered in the study and provided written informed consent prior to participating in the study.

Inclusion and exclusion criteria

The inclusion criteria for the enrolment of the subjects were the following:

- 20-40 years old;
- 15-30 Kg/m^2 body mass index

The exclusion criteria were:

- neurological, rheumatic or tumoral diseases;
- pathologies or physical conditions incompatible with the use of magnetic resonance imaging and electrostimulation (i.e., active and passive implanted biomedical devices, epilepsy, severe venous insufficiency in the lower limbs, pregnancy);
- previous interventions or traumas to the joints of the lower limb.

Data processing

Dynamometry data

The torque data were first filtered with a zero-phase shift 4th order Butterworth lowpass filter (frequency cutoff = 20 Hz) and converted in Nm (from mV), according to the following equation:

$$T_{Nm} = T_V \times 706.32$$

where T_V (i.e., the output force from the dynamometer in mV) is multiplied by the conversion factor provided by the vendor.

EMG data

The EMG signals were initially filtered within the 20-300Hz band using a zero-lag 5th order Chebyshev high-pass filter, followed by an 8th order Chebyshev lowpass filter. To remove the 50Hz noise frequency and its higher harmonics, a recursive filter was then applied. Then, the linear envelope, the root mean square (RMS) and the average rectified (ARV) value were extracted.

For the linear envelope, the filtered EMG data were (1) rectified and (2) lowpass filtered with a 2Hz zero-lag 4th order Butterworth filter.

To compute the RMS envelope, for each maximal contraction, the following equation was used:

$$RMS = \sqrt{\frac{1}{N} \sum_{n=1+N(L-1)}^{NL} EMG[n]^2}$$

where L corresponds to the signal epoch equal to 200 ms and N is the number of samples in each epoch.

The ARV values were extracted according to the equation below:

$$ARV = \frac{1}{T} \int_0^T |EMG(t)| dt$$

where T is the time over the EMG channel.

MRI images (segmentations)

The axial MRI scans, saved in DICOM format, were imported in the Mimics Innovation Suite software (Materialise, Leuven, BE), and organized to ensure consecutive stacks of images were merged. Then, using the software Mimics (v23, Mimics Innovation Suite, Materialise, Leuven, Belgium), the volumes of the main hip/knee/ankle flexors and extensors (biceps femoris caput longum, biceps femoris caput breve, gracilis, iliacus, psoas, rectus femoris, sartorius, semimembranosus, semitendinosus, tensor fasciae latae, vastus intermedius, vastus lateralis, and vastus medialis) of both legs were manually or semiautomatically segmented, and exported in STL file format.

For more details on the data processing steps, please refer to the following paper:

Davico G, Labanca L, Gennarelli I, Benedetti MG and Viceconti M (2024) Towards a comprehensive biomechanical assessment of the elderly combining in vivo data and in silico methods. Front. Bioeng. Biotechnol. 12:1356417.
doi: 10.3389/fbioe.2024.1356417

Data structure

HA

HA01

DYN (3x CSV files per knee config)

- *EXT_75*
  - HA01_e75_torques_raw_data.csv – raw torque data
  - HA01_e75_torques_filt_data.csv – offset removed, then filtered
  - HA01_e75_torques_filt_max.csv – max values rep by rep
- *EXT_90*
- *FLEX_75*
- *FLEX_90*

EMG (Nx7x CSV files per knee config, with N = n° reps, grouped in subfolders)

- *EXT_75* – one folder per knee configuration on dynamometer
  - rawData – raw data (as collected), divided rep by rep
    - HA01_e75_emg_raw_data_r1.csv
  - filtData – all filtered data
    - *01_filt* - offset and 50Hz removed, band-pass filtered
      - HA01_e75_emg_filt_data_r1.csv
    - *02_env* – linear envelope of the filt data
      - HA01_e75_emg_env_data_r1.csv
    - *03_rms* – rms envelope of the filt data
      - HA01_e75_emg_rms_data_r1.csv
    - *04_arv* - arv envelope of the filt data
      - HA01_e75_emg_arv_data_r1.csv
    - *05_normEnv* – normalized linear envelope (wrt max val)
      - HA01_e75_emg_nEnv_data_r1.csv
  - maxValues – max values rep by rep
    - HA01_e75_emg_env_max_r1.csv
- EXT_90
- *FLEX_75*
- *FLEX_90*

MRI

- *MuscleVolumes (only thigh muscles)*
  - HA01_side_muscle_name.stl – semiauto segmented, checked

Demographics.csv – age, sex, height, mass, side (for the entire cohort)

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e/f75 = extension/flexion @75° (dynamometer angle), **r#** = repetition #, **emg** = electromyography, **torques** = dynamometer torques, **filt** = filtered data, **max** = max values, **env** = linear envelope, **rms** = root mean squared envelope, **arv** = average rectified value, **side** = leg

Data types and units

FOLDER	FILENAME	TYPE	UNIT
DYN/task	HA01_e75_torques_raw_data	torques profiles	mV
DYN/task	HA01_e75_torques_filt_data	torques profiles	Nm
DYN/task	HA01_e75_torques_filt_max	value	Nm
EMG/task/rawData	HA01_e75_emg_raw_data_r1	sEMG data	mV
EMG/task/filtData	HA01_e75_emg_filt_data_r1	sEMG data	mV
EMG/task/filtData	HA01_e75_emg_env_data_r1	sEMG envelope	mV
EMG/task/filtData	HA01_e75_emg_rms_data_r1	sEMG envelope	mV
EMG/task/filtData	HA01_e75_emg_arv_data_r1	sEMG envelope	mV
EMG/task/filtData	HA01_e75_emg_nEnv_data_r1	sEMG envelope	[0,1]
EMG/task/maxValues	HA01_e75_emg_env_max_r1	value	mV
MRI/MuscleVolumes	HA01_side_muscle_name	3D shape	-