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IARIA

ANALYSIS OF UPPER LIMB CONTRACTION PATTERN USING ELECTROMYOGRAPHIC SIGNAL DURING ACTIVITIES OF DAILY LIVING: A PILOT STUDY

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A Summary of the Presenting Author

ACADEMIC AREA

- ✓ PhD student in Biomedical Engineering at the Faculty of Sciences and Technology of NOVA University of Lisbon (FCT/UNL).
- ✓ Master in Neuropsychology from the Institute of Health Sciences of the Portuguese Catholic University (2019).
- ✓ Bachelor's Degree in Occupational Therapy from the Superior School of Health of Alcoitão (2006).
- ✓ Invited Assistant Professor at the Superior School of Health of Polytechnic of Beja (since 2018)

PROFESSIONAL PRACTICE

- ✓ Occupational Therapist in a hospital context in the area of Physical Medicine and Rehabilitation in an adult population with neurological dysfunction (until 2018)

SCIENTIFIC AREAS OF INTEREST

- ✓ Occupational Performance, Biomedical Engineering, Biomechanics, Anatomy and Neurological Diseases

Summary

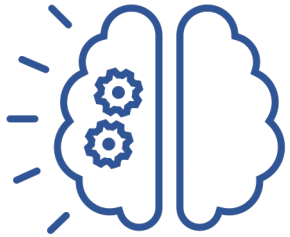
- Problem definition
- Goals
- Materials and methods
- Results
- Discussion of results and main conclusions

Problem definition

ADLS performance

Functional Movements

Upper Limb



STROKE

- → Decreased muscle strength [4];
- → Omission small actions in ADLs [7];
- → Decreased quality of performance in preparation of meals [7] and hygiene [8];

Problem definition

Conventional assessment methods are based on **qualitative scales** [9]

Characteristics of the **contraction patterns** of the upper limb during ADLs in healthy individuals.

Comparative baseline

TECHNOLOGY

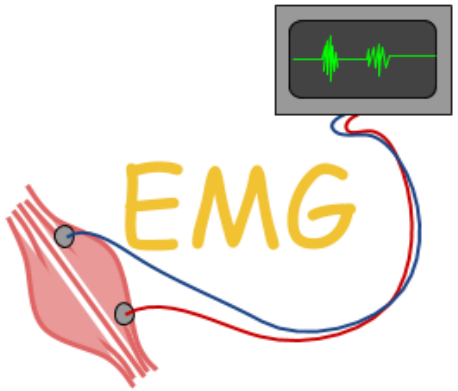
Most of them focus on the study of kinetic and kinematics, and not on biosignals parameters [10-12],[14],[15];

A few of them using technology tools such as optoelectronic motion analysis systems and inertial measurement sensors, in drinking from a glass activity [10-13],[15];

Only two of them analyzed the pattern of contraction of the upper limb muscles in ADLs [13-16]

Problem definition

TECHNOLOGY

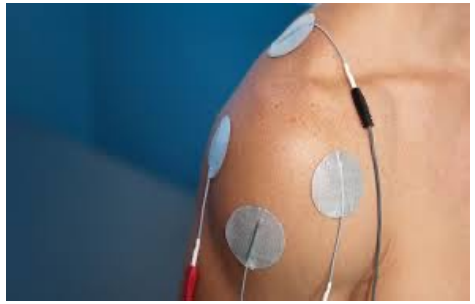


DETECTED COMPENSATORY MOVEMENTS

(based on altered movement patterns through the contraction of other muscles [13])

- Decrease in strength
- Alteration of tone

WHAT IS THE NORMAL PATTERN OF MUSCLE ACTIVATION IN ADLs??



Negative impact on join alignment

Limit range of motion

Muscle contractures

Weaknesses

Impairing the rehabilitation process

Problem definition

Analysis of the muscle activations of upper limb in the activity drinking from a glass

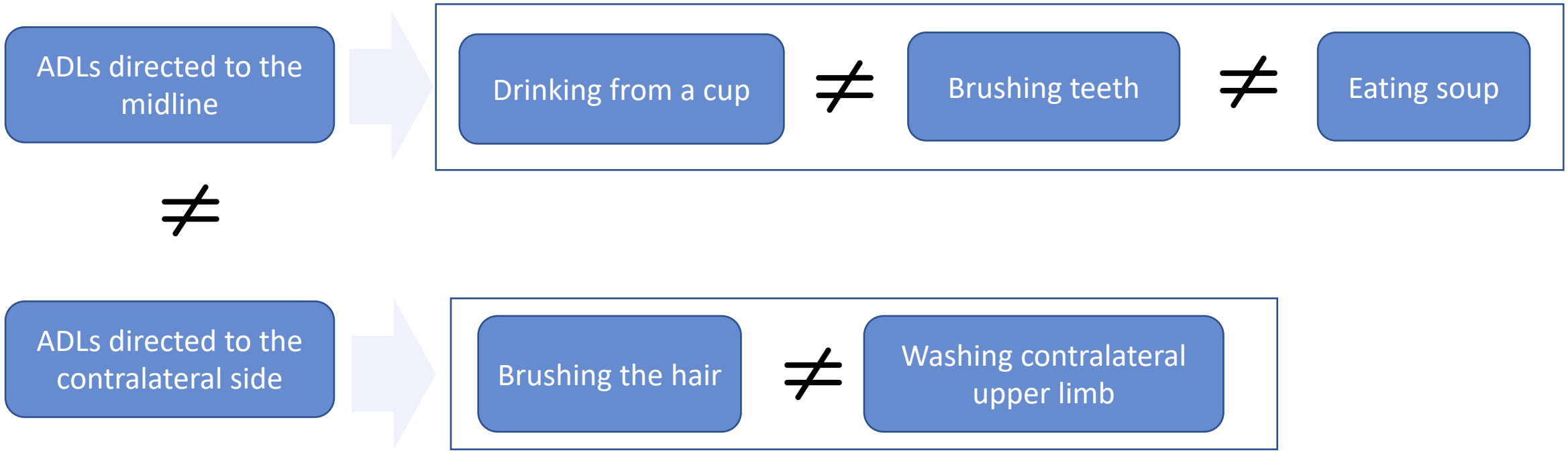
Sequence of muscles amplitude activation in ADL of drinking from a glass differs between **healthy and stroke patients** [13]

MUSCLES	Activation in Healthy Subjects	Activation in Stroke Subjects
Upper Trapezius	In the phases of taking the glass to the mouth and returning to the table	In all phases of activity
Anterior Deltoid	In “initial position to reach”	All in “initial position to reach”, ”reach for the cup” and ”carry to mouth”
Middle Deltoid	In ”carry to mouth”	
Posterior Deltoid	In “return to the pick up point” and “return to the initial position”	

Problem definition

Analysis of the muscle activations of upper limb in ADLs directed to the middle line and contralateral side

Sequence of muscles activation amplitude differs between activities on maximum peak of contraction amplitude [16]



Goals

WHAT IS THE NORMAL PATTERN OF MUSCLE ACTIVATION IN ADLs IN THE AREAS OF HYGIENE, PERSONAL CARE AND MEAL IN HEALTHY INDIVIDUALS?!

Explore and analyze the characteristics of the activation pattern of the EMG activity (amplitude and sequence of muscles activation peaks) of the shoulder main muscles during the ADLs.

Material and Methods

PARTICIPANTS

- ✓ 24 healthy individuals selected by convenience
- ✓ 6 were excluded due to failure to capture the EMG signal
- ✓ Sample with **n=18** individuals
- ✓ Mean age of 29.1 years ± 3.2 in a range **19-62 years;**
- ✓ 6 men and 12 women
- ✓ 17 were dominant right-handers.

Experimental procedure

→ Exclusion criteria: diagnosis of neuromotor disease, cognitive or language deficits, changes in visual acuity not corrected.

→ Ethical and confidentiality principles were guaranteed.

Material and Methods

MEASUREMENT SYSTEM

- → Devices used to collect EMG signals
- → Connected by wireless with OpenSignals (r)evolution Software ®.
- → Software used for data acquisition, visualization and processing signals.

Table 1. Placing electrodes on agonist muscles of the main shoulder movements.

Muscle	PM	AD	MD	PD	UT	LT
Shoulder movements	ADD	F	ABD	E	SE	SD
Electrode's position						

Abbreviation: PM, Pectoralis Major; AD, Anterior Deltoid; MD, Middle Deltoid; PD, Posterior Deltoid; UT, Upper Trapezius; LT, Lower Trapezius; ADD, Adduction; ABD, Abduction; F, Flexion; E, Extension; SE, Scapular elevation; SD, Scapular depression.

Material and Methods

EXPERIMENTAL PROCEDURE

ACTIVITIES TO THE MIDLINE

- → Drinking from a cup
- → Eating soup
- → Brushing teeth

- → Seated in a chair (45 cm high), next to a table (75 cm), knees and hips flexed at 90º ;
- → Upper limbs resting on a table, shoulder in neutral position, elbow flexed at 90º , forearm in pronation, wrist in neutral position and fingers in extension;

ACTIVITIES TO THE CONTRALATERAL SIDE

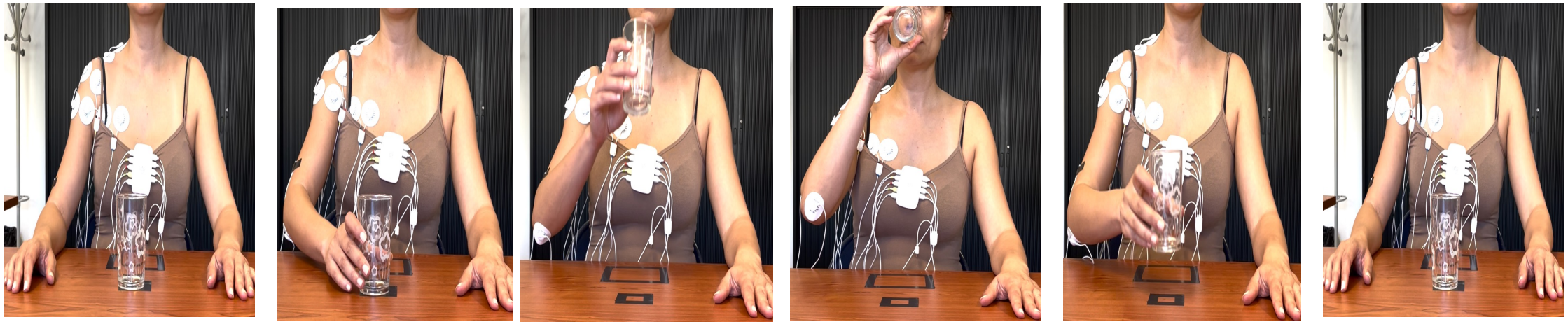
- → Washing contralateral upper limb
- → Brushing the hair on the contralateral side

- → Seated in a chair (45 cm high), knees and hips flexed at 90º ;
- → Upper limbs supported on the thighs, shoulder in neutral position, elbow flexed at 45º, forearm and wrist in neutral position and fingers semi-flexed.

Material and Methods

EXPERIMENTAL PROCEDURE

PHASES OF ACTIVITIES DIRECTED TO THE MIDLINE [10],[11]

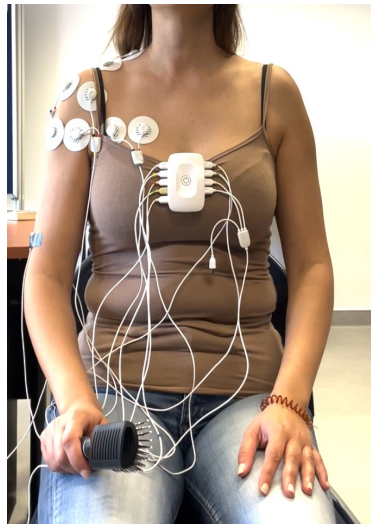
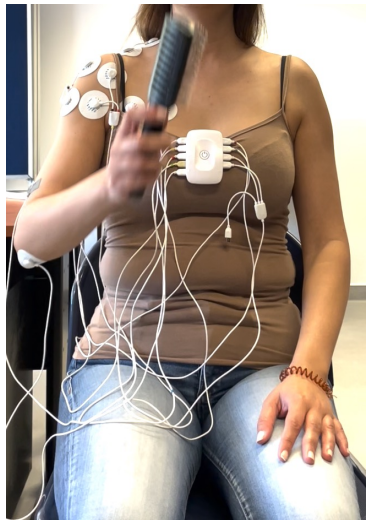
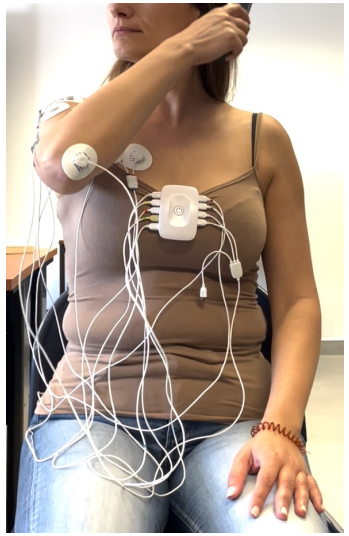
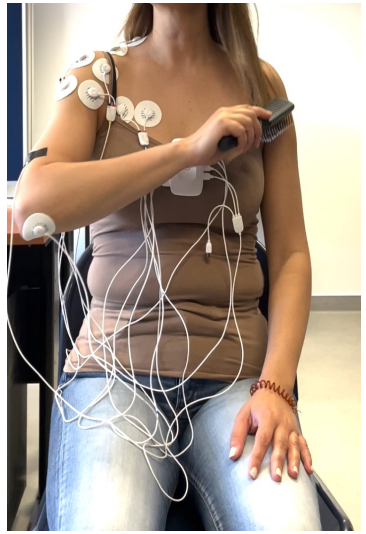
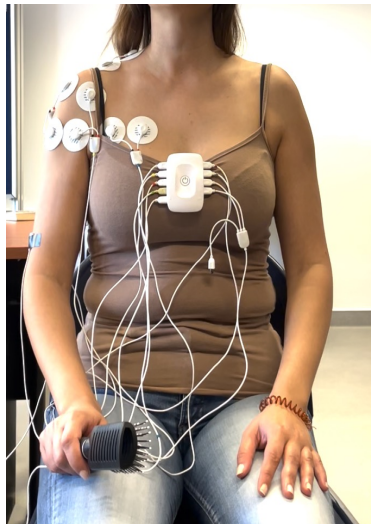


Phases	1.Starting position to reaching	2.Grasping	3.Transporting to the mouth	4.Introduced in the mouth	5.Return to the pick point	6.Return initial position
Movements						
Drinking	ADD, F	ADD, F, SE	F, ABD, SE	F, ABD, SE	ADD, E, SE	E, SE, ABD
Eating soup	ADD, F, SE	ADD, F, SE	F, ABD, SE	F, ABD, SE	ADD, E, SE	E, SE, ABD
Brushing teeth	ADD, F, SE	ADD, SE, F	F, ABD, SE	F, ABD, SE	ADD, E, SE	E, SE, ABD

Material and Methods

EXPERIMENTAL PROCEDURE

PHASES OF ACTIVITIES DIRECTED TO THE CONTRALATERAL SIDE [10],[11]

Phases	1. Grasping	2. Transporting to the contralateral side	3.Reaching the contralateral side	4.Return to the thigh	5.Return initial position
Movements Hair brushing Washing upper limb	ADD	F, ADD, SE	F, ADD, SE	E, ABD, SD	E, ABD, SD

Material and Methods

Signal processing

EMG channels were selected → Epochs of 7000 points were chosen to analyze → Sample rate was used to transform samples into time variable (*t*(s)) → The signal was zero centered (the mean of the signal was subtracted)

The absolute value of the signal was taken → A moving mean filter was applied → The amplitude of the peaks of activation amplitude and time where they occur were determined. → Maximum values of the amplitude were saved.

Results

BETWEEN ACTIVITIES DIRECTED TO THE MIDLINE

TABLE III. MEANS OF THE AMPLITUDE AND TIME OF PEAKS OF MAXIMUM AMPLITUDE OF THE ACTIVITIES DIRECTED TO THE MIDLINE.

	MEANS OF THE AMPLITUDE AND TIME OF PEAKS OF MAXIMUM AMPLITUDE					
	Drinking		Eating soup		Brushing teeth	
	Amplitude contraction peak (mV)	Time amplitude peak (s)	Amplitude contraction peak (mV)	Time amplitude peak (s)	Amplitude contraction peak (mV)	Time amplitude peak (s)
Pectoral Major	367 ±37	2.83 ±0,25	639 ±408	3.08 ±0,30	448 ±90	3.57 ±0,20
Anterior Deltoid	1970 ±218	2.42 ± 0,08	1665 ±239	2.73 ±0,23	1355 ±138	4.13 ±0,33
Middle Deltoid	1203, ±134	2.96 ±0,26	1144 ±132	2.30 ±0,26	757 ±63	5.05 ±0,46
Posterior Deltoid	413 ±39	3.43 ±0,28	402 ±42	2.24 ±0,22	341 ±34	4.01 ±0,55
Upper Trapezius	1893 ±265	2.56 ±0,24	2244 ±337	2.53 ±0,17	1976 ±238	4.42 ±0,41
Lower Trapezius	532 ±83	2.71 ±0,29	375 ±56	2.88 ±0,37	1445 ±1005	3.55 ±0,50

- → There is a different activation amplitude pattern between all activities;
- → The only similarity is verified in the group of muscles that present greater amplitudes (AD, MD and UT) in ADLs drinking from a cup and eating soup;
- → Brushing teeth has two of the previous ADLs in common: the UT and AD;
- → The averages of peak activation amplitude peaks occur between 2.24s and 5.05s , with drinking from a glass and eating soup activities being the most similar.

Results

EXAMPLE OF THE AMPLITUDE PATTERN OF MUSCLES ACTIVATIONS OVER TIME OF ACTIVITIES DIRECTED TO THE MIDLINE

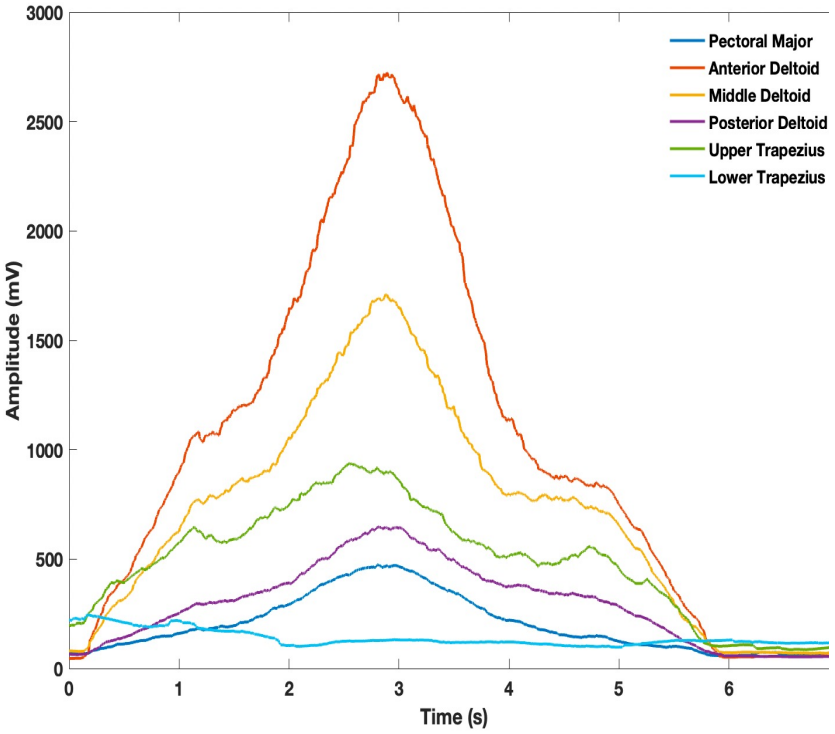


Figure 1- Amplitude pattern of muscle activation over time of drinking

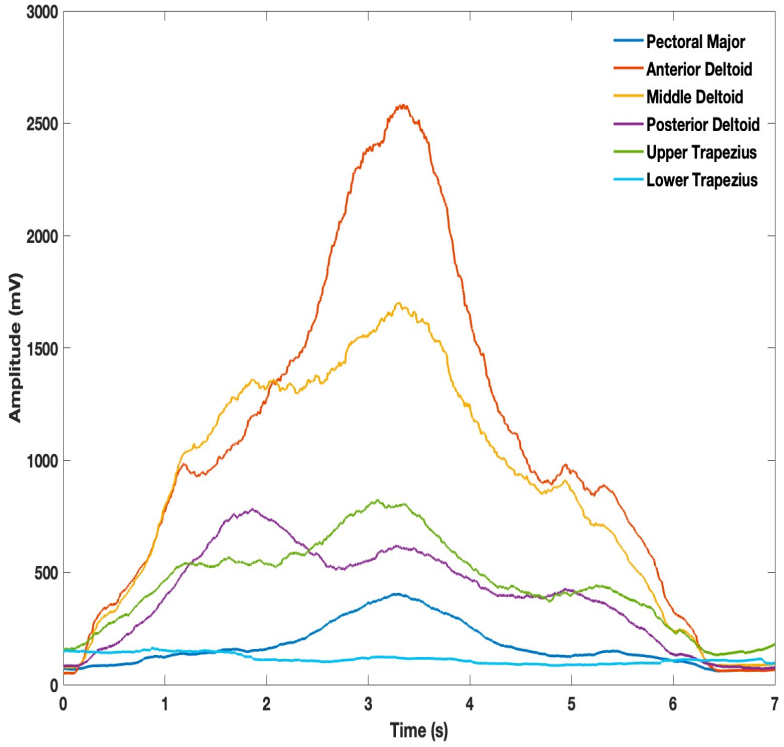


Figure 2- Amplitude pattern of muscle activation over time of eating soup

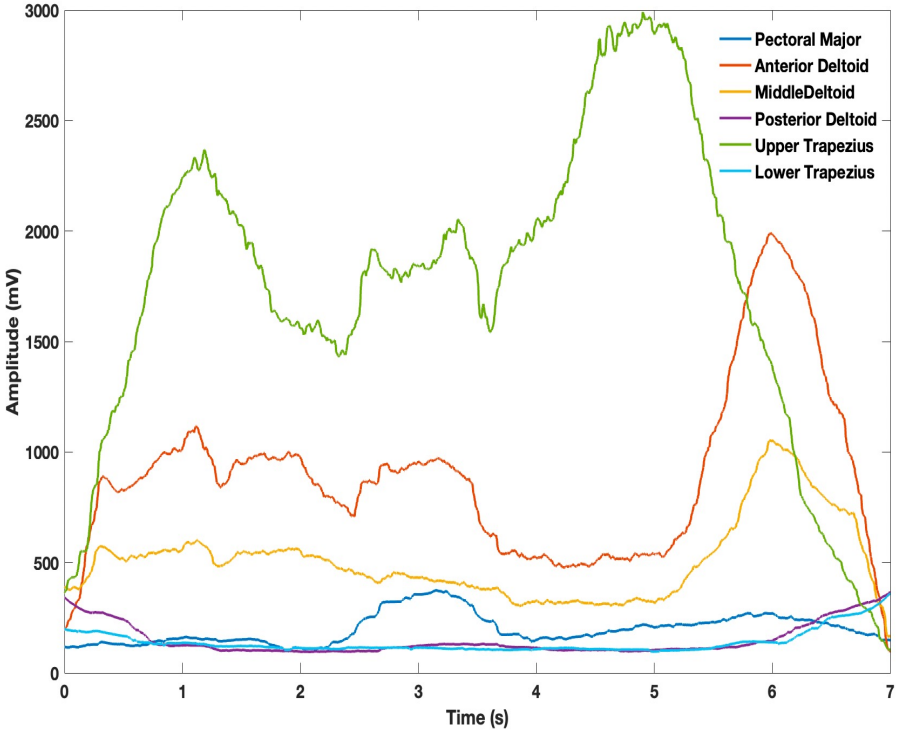


Figure 3- Amplitude pattern of muscle activation over time of brushing teeth

Results

BETWEEN ACTIVITIES DIRECTED TO THE CONTRALATERAL SIDE

TABLE IV. MEANS OF THE AMPLITUDE AND TIME OF PEAKS OF OF THE ACTIVITIES DIRECTED TO THE CONTRALATERAL SIDE

	ACTIVITIES TO THE CONTRALATERAL SIDE			
	Arm washing		Brushing the hair	
	Amplitude contraction peak (mV)	Time amplitude peak (s)	Amplitude contraction peak (mV)	Time amplitude peak (s)
Pectoral Major	1190 ±181	1.72 ±0.10	855 ±135	1.71 ±0.10
Anterior Deltoid	2171 ±23	1.46 ±0.71	3134 ±360	1.52 ±0.80
Middle Deltoid	1112±117	2.20 ±2.67	1891 ±220	1.67 ±0.10
Posterior Deltoid	538 ±80	2.15 ±0.27	550 ±44	1.92 ±0.25
Upper Trapezius	1216 ±145	1.88 ±0.28	1952 ±269	1.57 ±0.16
Lower Trapezius	382 ±40	1.73 ±0.16	413 ±46	1.59 ±0.10

- → There is a different activation amplitude pattern between all activities;
- → The only similarity is verified in the group of muscles that present greater amplitudes (AD, UT);
- → The averages of peak activation amplitude peaks occur between 1.46s and 2.20s.

Results

EXAMPLE OF THE AMPLITUDE PATTERN OF MUSCLES ACTIVATIONS OVER TIME OF ACTIVITIES DIRECTED TO THE CONTRALATERAL SIDE

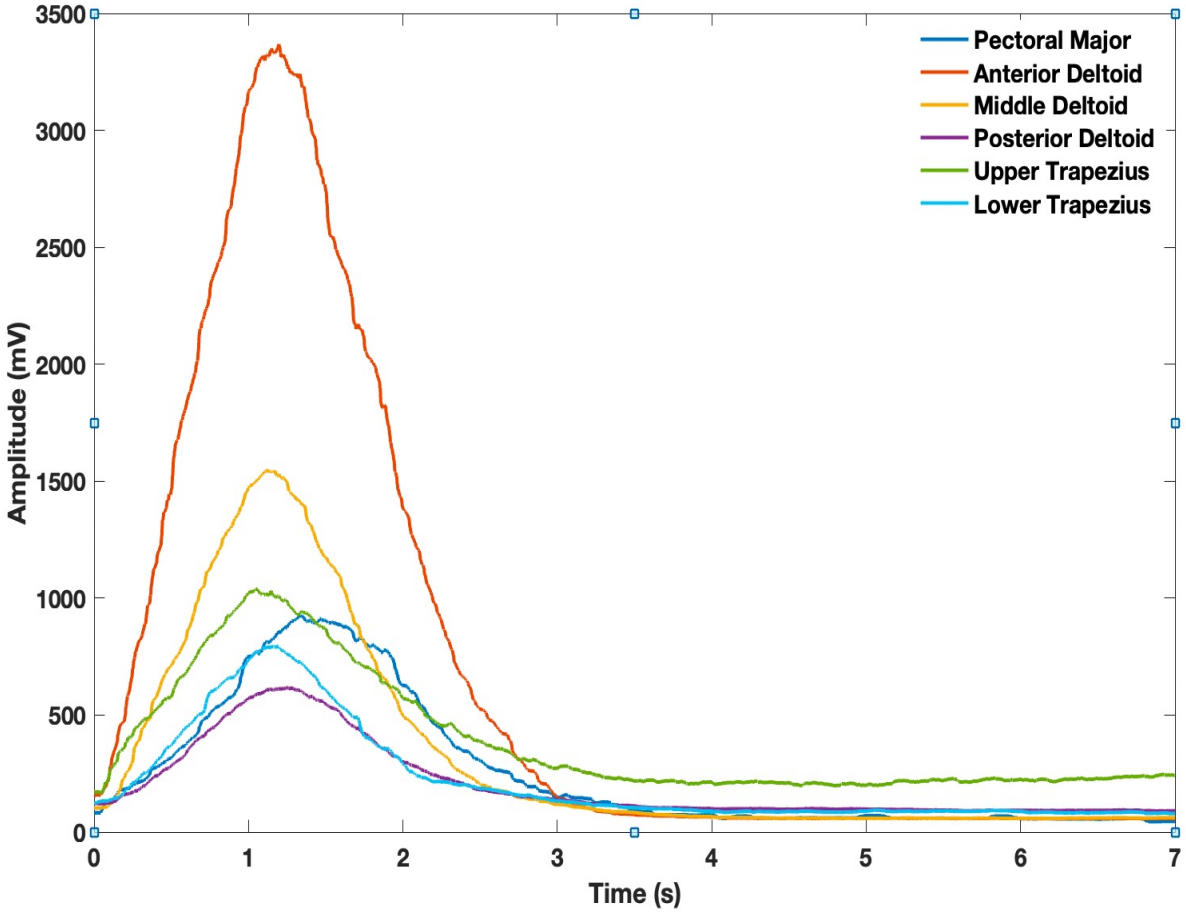


Figure 4 - Amplitude pattern of muscle activation over time of arm wash activity.

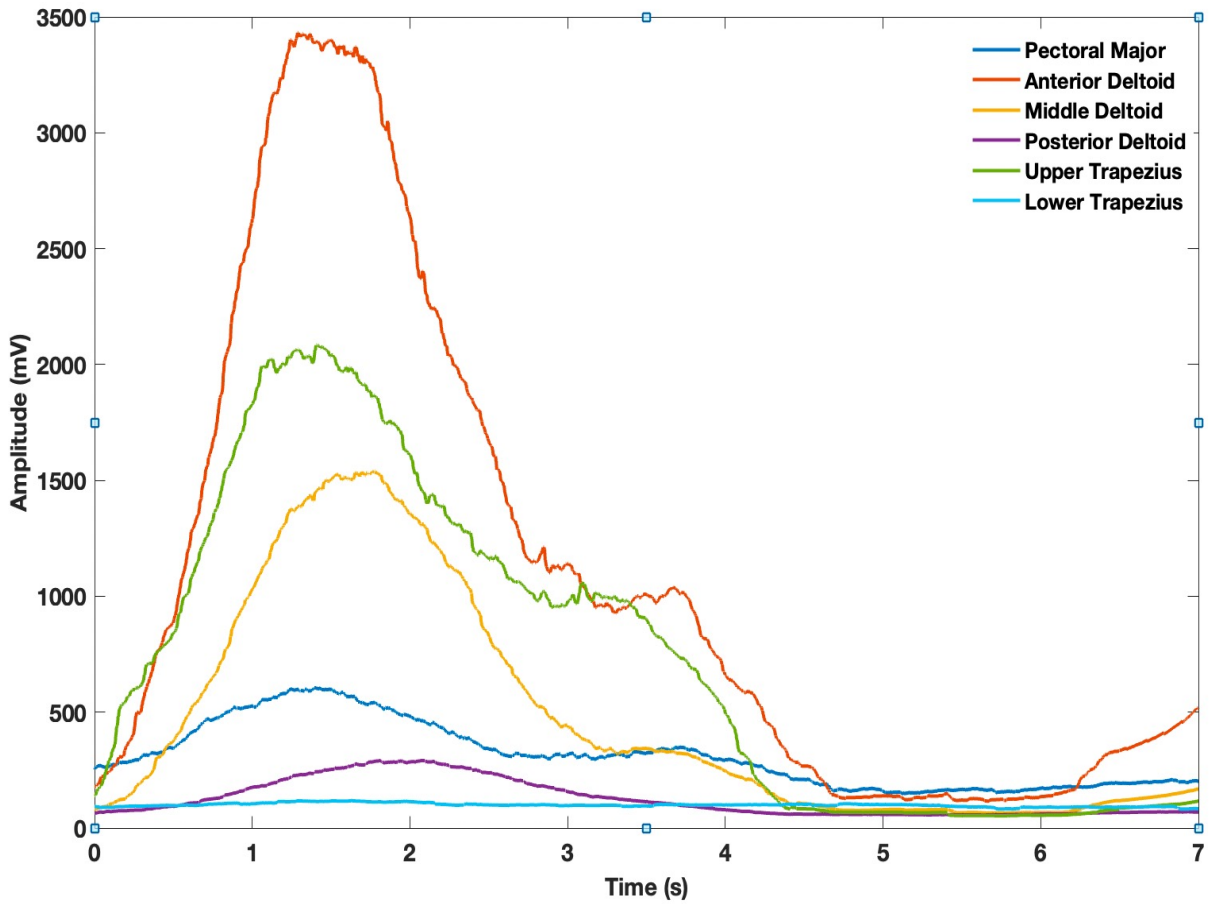


Figure 5 - Amplitude pattern of muscle activation over time of brushing hair.

Discussion and main conclusions

The results are indicative that the average times in which amplitude peaks occur…

ADLs directed to the midline

→ In all ADLs occur between 2.24s and 5.05s
→ **In drinking and eating soup occur around 2-3s**
→ In brushing teeth occur around 3-5s

Reinforces the results of our previous study [16]

ADLs directed to the contralateral side

→ **In all ADLs occur between around 1s and 2s**

Reinforces the results of our previous study [16]

Discussion and main conclusions

→ Considering the phases of activities, the results reinforce previous studies [11],[16],[24].

ACTIVITIES DIRECTED TO THE MIDLINE

Phase of contraction

- 1st Starting position to reaching
- 2nd Grasping
- 3rd Transporting to the mouth
- 4th Introduced in the mouth

Phase of decreased contraction

- 5th Return to the pick up point
- 6th Return initial position

During the activity time….

ACTIVITIES DIRECTED TO THE CONTRALATERAL SIDE

Phase of contraction

- 1st Grasping
- 2nd Transporting to the mouth
- 3rd Introduced in the mouth

Phase of decreased contraction

- 4th Return to the pick up point
- 5th Return initial position

During the activity time….

Discussion and main conclusions

ACTIVITIES DIRECTED TO THE MIDLINE

The results are indicative that:

- Drinking from a glass
- Eating soup
- Brushing the teeth

DIFFERS

- → There is a different activation amplitude pattern between all activities;
- → The group of muscles that present greater amplitudes (AD, MD and UT) in ADLs drinking from a cup and eating soup, are similar;
- → Brushing teeth has in common with the two previous ADLs the UT and AD;

Reinforces the results of our previous study [16]

Different requirements of the ADLs in each phase

Different procedures lead to different amounts of muscle fibers being recruited in the same muscles.

Discussion and main conclusions

ACTIVITIES DIRECTED TO THE CONTRALATERAL SIDE

The results are indicative that:

Washing the arm

Brushing the hair

DIFFERS

→ There is a different activation amplitude pattern between all activities;

→ The only similarity is verified in the group of muscles that present greater amplitudes (AD, UT);

Reinforces the results of our previous study [16]

Different requirements of the ADLs in each phase

Different procedures lead to different amounts of muscle fibers being recruited in the same muscles.

Discussion and main conclusions

CONCLUSIONS

- Although the related muscle groups of the shoulder involved in the ADL's are the same, the specificities of the activity point to the **existence of different patterns of muscle contraction** between the **ADL's** analyzed.

- Differences in the pattern of activation amplitude between:
  - ADLs directed to the midline,
  - ADLs directed to the contralateral side,
  - Between these two groups of activities.

- Similarities on the time interval in which peaks of muscle activation occur during activities.
  - ADLs directed to the midline (drinking from a cup and eating soup);
  - ADLs directed to the contralateral side;

Discussion and main conclusions

CONCLUSIONS

- These results lead to the need for **future work** to understand whether these indications are valid **in a larger sample**, with an average age closer to the average of subjects with stroke;
- A **data analysis that includes the normalization** of the amplitude of muscle activation throughout the activities relating it with the different phases of the activities;
- The use of **EMG together with other technologies**, such as accelerometry and and optoelectronic motion capture systems, for example, to complement the analysis of the shoulder muscle contraction pattern;
- This study thus **contributed to establish a normative behavior of shoulder movements during ADLs** in a healthy population, which, in the future, can be compared with the results using the same experimental protocol in patients with pathologies such as stroke.

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Thank you for your time!

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