Developing an Optimized EMS User Guide to Enhance Muscle Architecture

https://kidsdiscover.com

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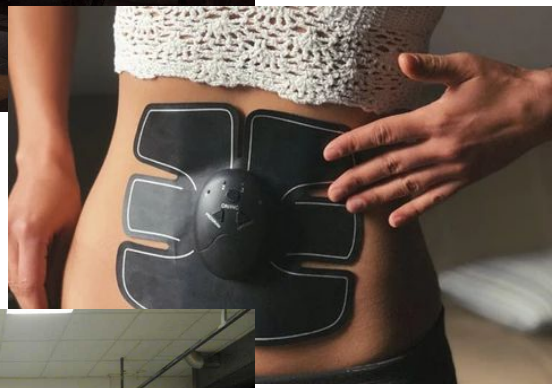
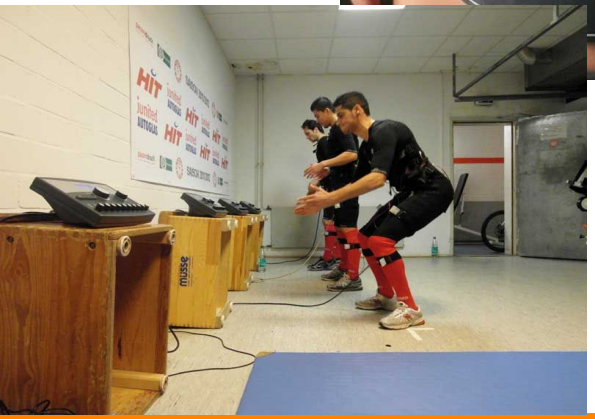
Project Aims

1. Evaluate prior studies involving electromyostimulation (EMS) to determine its effect on muscle cross-sectional area, torque, and pennation angle
2. Compile the results of the previous investigations to determine an effective plan-of-use for EMS
3. Test this plan-of-use in different population groups in order to ensure adequate applicability





EMS:

The use of electrical impulses to elicit muscle contractions

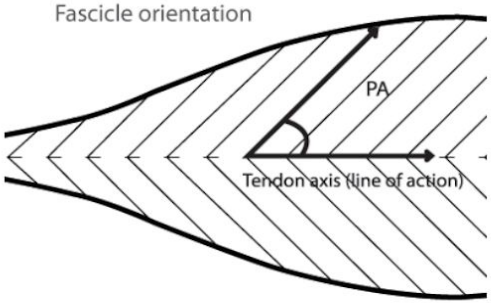
- Leads to significant changes in :
  - Muscle cross-sectional area
    - Pennation angle
      - Muscle torque

https://www.shocktherapyfitness.com/
https://www.lazada.com.ph/shop-core-abdominal-trainers/
https://www.nancyandersonfit.com/blogs/news/ems-training-is-this-new-fitness-craze-legit

Importance of Affected Muscle Architecture Properties

Cross Sectional Area: property of muscle architecture that is directly proportional to the force that a muscle can generate

$$F_o^m \ \alpha \ \text{PCSA}$$



https://www.tandfonline.com/doi/full/10.1080/10255842.2014.917294

Pennation Angle: The orientation between a muscle fascicle and tendon.

$$\mathbf{f}_t = \sum_i \mathbf{f}_m^i \cos(\text{PA}^i).$$

Muscle Torque: The ability of force to cause a rotation about a lever. The greater the torque, the greater the movement produced on the body's "levers."

Potential Impact

Users

In the US alone:

- 16 million adults have COPD
- 68.7 people are over the age of 60 years old
- ~5,000 professional athletes
- ~45 million adults have a gym membership

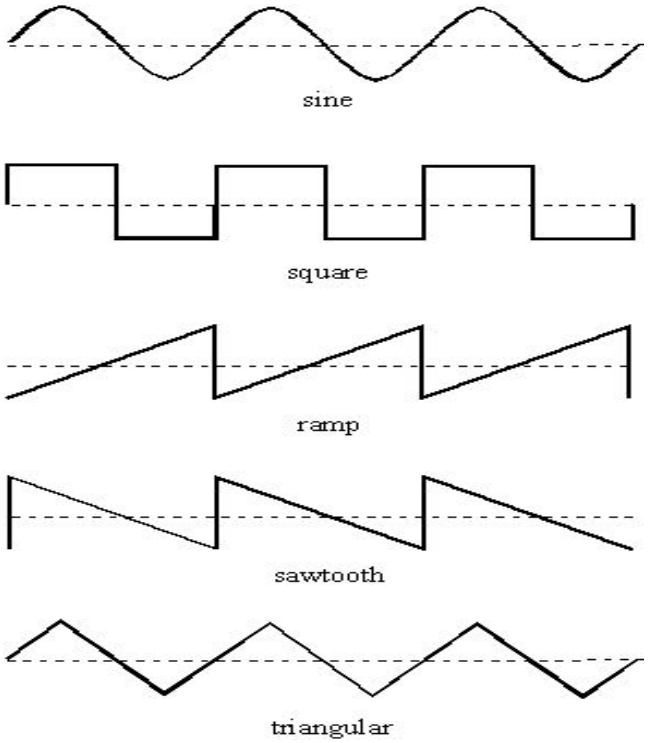
Estimated Cost

- Electrodes:~$15/40 pads
- Portable Stimulator: ~$250-500

https://www.compex.com

Variables in EMS

- Total Weeks
- Sessions/week
- Impulse Interval
- Impulse Waveform
- Impulse Frequency
- Impulse on-time



https://whatis.techtarget.com/definition/waveform

Aim 1: Cross Sectional Area

Authors	n	Sex	Age	Sessions/ week	Total Weeks	Impulse Interval	Impulse Form	Impulse Frequency	Impulse On-Time	Percent Difference
Gondin et al.	22	male	23.5±5	4	8	18 min sessions	Rectangular wave, pulse	75 Hz	400 μs	3-10% increase
Vivodtzev et al.	22	8 male 4 female	70±1	5	6	35 min quadriceps; 25 min calf	Not mentioned	50 Hz	400 μs	6%±2% increase in both
Oliveira et al.	33	male	22.1±2.6	3	6	15 min sessions	Medium is biphasic (rectangular/sinusoidal)	Low: 1-100 Hz Medium: 1-10 kHz	500 μs	Thicker muscles
De Abreu et al.	15	Male (quadriplegia)	32.2±3.5	2	24	20 min sessions	NMES	25 Hz	300 ms	15% increase
Lotri-Koffi et al.	23	C57BL6 male mice	16-week old	5	2.5	20 min sessions	symmetrical , biphasic, square-pulsed	50 Hz	150 μs	~6% increase

Aim 1: Pennation Angle

Authors	n	Sex	Age	Sessions/week	Total Weeks	Impulse Interval	Impulse Form	Impulse Frequency	Impulse On-Time	Percent Difference
Gondin et al.	22	Male	23.5±5	4	8	18 min sessions	Rectangular wave, pulse	75 Hz	400 μs	14±7% increase
Oliveira et al.	33	male	22.1±2.6	3	6	20 min sessions	Medium is biphasic (rectangular/sinusoidal)	Low: 1-100 Hz Medium: 1-10 kHz	500 μs	No difference

Aim 1: Torque

Authors	n	Sex	Age	Sessions/ week	Total Weeks	Impulse Interval	Impulse Form	Impulse Frequency	Impulse On-Time	Percent Difference
Maffiulett i et al.	8	male	20.4±2.1	4	4	18 min sessions	Rectangular wave, pulse	75 Hz	400 μs	8.1-10.8% increase
Oliveira et al.	33	male	22.1±2.6	3	6	15 min sessions	Medium is biphasic (rectangular/s inusoidal)	Low: 1-100 Hz Medium: 1-10 kHz	500 μs	Alternating: 19.6% Pulsed: 17.8%
Colson et al.	25	male	24±2.5	3	7	5 sets of 6 contractions every 3 minutes	Rectangular wave, pulse	80 Hz	240 μs	At 120°: +15.9±4% At 60°: +18.2±5% At 30°: +15.8±4%

Aim 2: EMS Plan-of-Use

- Frequency of EMS training sessions:
  - 3 times per week
  - 20 min sessions
  - 8 weeks or more
- Intensity: gradually increase until the maximum tolerated
- Waveform: Biphasic
- Frequency: 75 Hz
- Impulse on-time: 400 μs

Aim 3: Testing

Conduct three 8-week studies that use the previously outlined plan to test changes in quadricep muscle architecture properties in the following groups:

1. COPD patients - 30 total participants (Experimental (15) & Control (15))
    a. Age: 45-55 years old
2. Athlete Group - 30 total participants (Experimental (15) & Control (15))
    a. *These participants will be from the same sports team*
3. Young Adults - 30 total participants (Experimental (15) & Control (15))
    a. 20-25 years of age

Testing Conditions

Equipment:

- Cross Sectional Area Measurements:
  - B-mode ultrasonography
- Pennation Angle Measurements:
  - B-mode ultrasonography
- Torque Measurements:
  - Biodex-type Isokinetic Ergometer: measure muscle contractions

https://m.biodex.com/physical-medicine/blog/what-isokinetic-testing

Constant variables:

- Time EMS sessions are held
- 60° knee flexion
- Frequency

Expected Results

We expect to see:

- Significant increases in muscle architecture properties for each experiment
- Comparable changes between experiments

If the changes are not significant in one group, then we will reevaluate our EMS plan for the specific population group and test again.

Table 1. Quadriceps cross-sectional area of each individual in the gait group

Gait group	Level of injury	Cross-sectional area (cm^2)	
		Before	After
1	C5	60.2	73.3
2	C4	59.1	69.3
3	C5	57.2	60.7
4	C4	38.9	53.0
5	C4	47.5	51.4
6	C5	48.5	52.8
7	C7	34.5	41.1
8	C6	52.5	56.9
Mean		49.8	57.3
Standard deviation		9.4	10.3

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Thank You!

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