



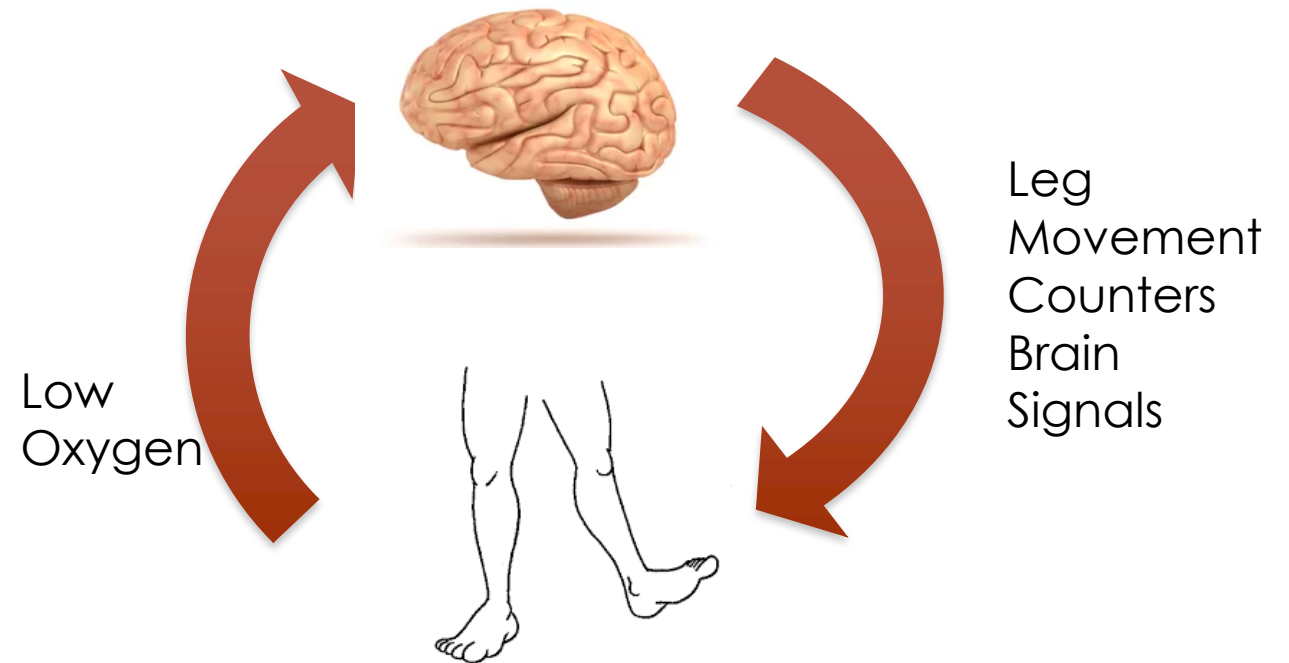
Periodic Leg Movement Exercise Device

Progress Presentation

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Background


- ▶ PLMS (Periodic Leg Movement Syndrome) = **uncontrollable jerking** of legs and arms during sleep
- ▶ Affects **3.9%** of the total population
 - ▶ Spinal cord injuries, transverse myelitis, and other neural pathologies
- ▶ **Counter stimulation** used to counteract brain signals
 - ▶ Relieves restless leg syndrome (RLS), similar to PLMS



Changes From Preliminary Report

- ▶ There is a need for a device to lessen the frequency and severity of nighttime periodic leg movements experienced by individuals with multiple sclerosis, transverse myelitis, **spinal cord injuries or other neural pathologies** in order to allow them to comfortably sleep through the night.
- ▶ We propose to deliver to the client, BME faculty and students on the last day of class a prototype of an automated motion system which would include a **safe device that can move the user's legs back and forth without waking the individual, an interface that allows the user to decide if and when the device is turned on and at what intervals, and documentation and programming code used in creating the device**. The size and shape should allow the individual to use the equipment while sleeping in **any sized bed**, and the motion of the device should be easily controllable. Finally, the equipment should cost less than \$1,000, so that it is a financially feasible purchase for those who need it. The prototype of the device and interface will be made available to the client by May 2018.

Design Specifications




Specification	Metric	Weight
Frequency of movement	0.25 to 2.5 Hz	10
Displacement	0 to 30 cm	10
Force	< 150 N per leg	9
Weight	< 10 kg	7
Cost	< \$1000	9
Dimension	Length < 200 cm Width < 70 cm, half of the width of a full bed	5
Installation	Does not require daily disassembly/assembly 1 person sitting in a wheelchair can set up	6

Design Specifications

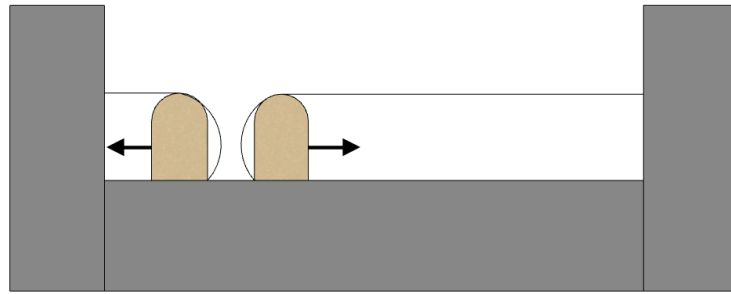
Specification	Metric	Weight
Adjustable to Individual	Fits any leg circumference up to 70 cm; Any leg length	6
Operating Time	At least 12 hours; Adjustable	8
Software Interface	Control while lying down; range of 6 ft; wide range of control: automatic mode for sleep; manual control for wake; Minimal interference	9
Safety	No short or long-term damage to user; No toxic materials or chemicals; No exposed electrical components Cords not harmful or disruptive to user Low friction: avoids sores due to friction over long term use	10
Comfort	Lifts legs < 20 cm above rest of body; < 1 kg weight attached to each leg; Should not be unpleasant to use, allows user to remain asleep; Allows user to shift positions throughout sleep (side, back, stomach, etc.)	8
Sound	< 30 dB _A	5
Due Date	May 1, 2018	10



Three Main Categories

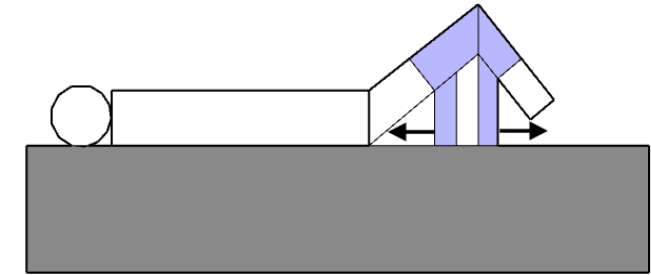
- Movement Apparatus
 - Software Interface
 - Power Supply
- 

Movement Apparatus



Leg Sleeves With Side to Side Motion (With and Without Vibrations)

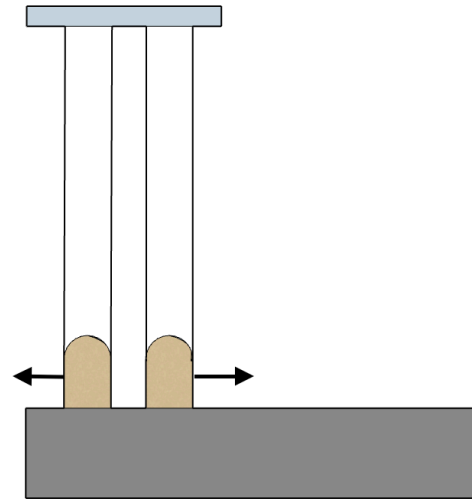
- Pros: cheap, adjustable
- Cons: unsafe, uncomfortable, difficult to install



"Knee Brace" Which Bends Legs at the Knee

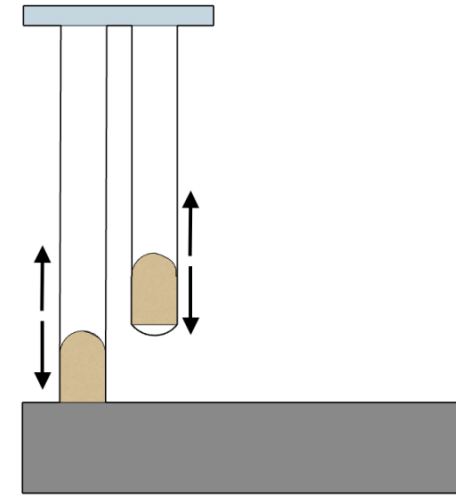
- Pros: adjustable, low sound, small dimensions
- Cons: unsafe, uncomfortable, low range of frequencies

Movement Apparatus



Straps With Side to Side Motion

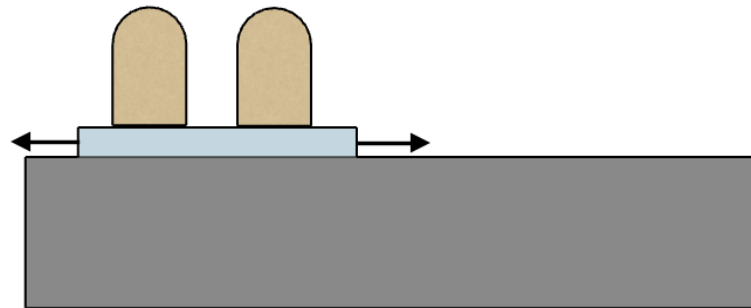
- Pros: cheap, low weight
- Cons: unsafe, difficult to install, too much displacement



Straps With Up and Down Motion

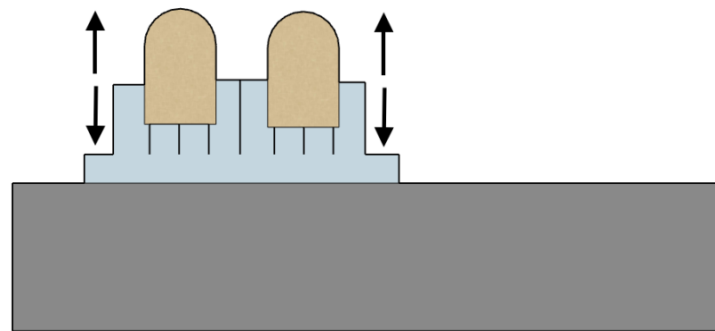
- Pros: cheap, low weight
- Cons: uncomfortable, unsafe, difficult to install

Movement Apparatus



Platform With Side to Side Motion (With and Without Vibration)

- Pros: comfortable, small dimensions, suitable force and displacement
- Cons: high frequency, slightly unsafe



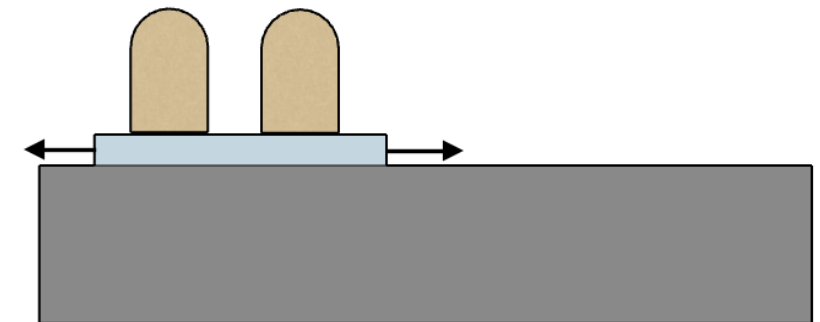
Inflatable Pad With Up and Down Motion (With and Without Vibration)

- Pros: safe, comfortable, small dimensions, easy installation
- Cons: low frequency and displacement, costly, loud

Movement Apparatus

	Weight	1	2	3	4	5	6	7	8	9	Gold Standard
Frequency of Motion	10	7	7	4	7	7	7	7	5	5	6
Displacement of legs	10	7	7	9	7	7	9	9	3	3	9
Force	9	7	7	5	5	5	9	9	7	7	10
Weight	7	7	6	8	8	8	8	7	10	9	8
Cost	9	8	7	7	9	9	8	7	5	4	10
Dimension	5	5	5	10	5	5	7	7	10	10	10
Installation	6	4	4	3	4	4	6	6	10	10	6
Adjustable	6	8	8	10	10	10	10	10	10	10	7
Comfort	8	6	5	2	5	5	7	6	9	8	3
Safety	10	5	5	5	4	4	7	7	10	10	7
Sound	5	6	5	9	6	6	6	5	3	2	6
Due Date	10	9	8	10	9	9	9	8	10	9	7
Total		639	600	633	631	631	746	707	715	676	708


- 1: Leg Sleeves with Side to Side Motion
 - 2: Leg Sleeves with Side to Side Motion with Vibration
 - 3: "Knee Brace" which Bend Legs at the Knee
 - 4: Straps with Side to Side motion
 - 5: Straps with Up and Down motion
 - 6: Platform with Side to Side motion
 - 7: Platform with Side to Side motion with Vibration
 - 8: Up and Down movement via Inflatable Pad
 - 9: Up and Down movement via Inflatable Pad with Vibration
- Gold Standard:** SunAncon Chi Machine



Platform With Side to Side Motion



Three Main Categories

- Movement Apparatus
 - Software Interface
 - Power Supply
- 

Software Interface

- Controls on Side of Movement Apparatus
 - Pros: simple, cheap, no interference
 - Cons: no range of motion, uncomfortable, unsafe
- External Device Connected Via Cord
- Wireless, External Remote Controller (RF)
- App Connected to Device via Bluetooth

Software Interface

- Controls on Side of Movement Apparatus
- External Device Connected Via Cord
 - Pros: simple, cheap
 - Cons: uncomfortable, unsafe
- Wireless, External Remote Controller (RF)
- App Connected to Device via Bluetooth

Software Interface

- Controls on Side of Movement Apparatus
- External Device Connected Via Cord
- Wireless, External Remote Controller (RF)
 - Pros: safe, comfortable, easy to use
 - Cons: Signal Interference
- App Connected to Device via Bluetooth

Software Interface

- Controls on Side of Movement Apparatus
- External Device Connected Via Cord
- Wireless, External Remote Controller (RF)
- App Connected to Device via Bluetooth
 - Pros: safe, comfortable, easy to use
 - Cons: signal Interference, narrow market

Software Interface


	Weight	1	2	3	4
Cost	9	10	9	9	9
Installation	6	10	10	8	5
Range	9	2	8	10	10
Safety	10	3	6	8	8
Operating Time	8	9	8	8	8
Due Date	10	10	10	10	10
Interference	8	10	9	7	7
Total		450	509	519	501

- 1:** Controls on side of movement apparatus
2: External Device connected via cord to movement apparatus
3: Wireless, external remote controller (RF)
4: App connected to device via Bluetooth

Wireless, External Remote Controller



Three Main Categories

- Movement Apparatus
 - Software Interface
 - Power Supply
- 

Power Supply

- Lithium Ion Battery
 - Pros: none
 - Cons: unsafe, large size and weight, low operating time
- Alkaline Battery
- External AC to DC Power Adapter
- Variable DC Bench Supply

Power Supply

- Lithium Ion Battery
- Alkaline Battery
 - Pros: cheap, safe
 - Cons: low operating time, low force
- External AC to DC Power Adapter
- Variable DC Bench Supply

Power Supply

- Lithium Ion Battery
- Alkaline Battery
- External AC to DC Power Adapter
 - Pros: sufficient operating time and power, cheap, light
 - Cons: none
- Variable DC Bench Supply

Power Supply

- Lithium Ion Battery
- Alkaline Battery
- External AC to DC Power Adapter
- Variable DC Bench Supply
 - Pros: sufficient operating time and power
 - Cons: unsafe, costly, bulky

Power Supply

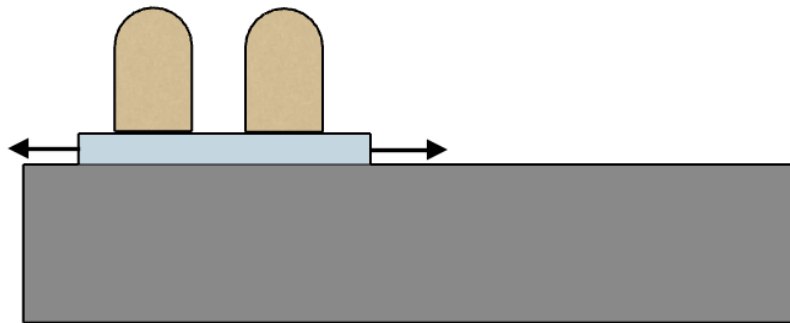
	Weight	1	2	3	4
Force	9	5	5	10	10
Weight	7	7	7	8	2
Cost	9	8	10	8	3
Dimension	5	5	5	10	2
Installation	6	8	3	8	6
Operating time	8	5	2	10	8
Comfort	8	10	10	8	5
Safety	10	8	10	8	8
Sound	5	10	10	10	8
Due Date	10	10	10	10	10
Total		589	573	690	501

- 1: Lithium Ion Battery
- 2: Alkaline Battery
- 3: External AC to DC Power Adapter
- 4: Variable DC bench supply

External AC to DC Power Adapter

Chosen Design Alternative

- Movement Apparatus: Platform With Side to Side Motion
 - Might add vibrations next semester
- Software Interface: Wireless, External Remote Controller (RF)
- Power Supply: External AC to DC Power Adaptor





References



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Questions?

Budget

Item	Cost	Source
High Quality, Durable Plastic	\$350	Online Metals
1" FoamTouch Upholstery Foam	\$19.99	Amazon
Cloth Covering	\$8	Joann Fabrics
DC 24V 15-30W 8000 RPM Motor	\$23.48	Walmart
6V-90V 15A DC Motor Pump Speed Controller	\$10.99	Amazon
Double Sided Non-Slip Yoga Mat	\$25.95	Amazon
Arduino Starter Kit	\$17.99	Amazon
Arduino Power Supply	\$5.99	Amazon
Arduino Mini	\$9.95	Adafruit
RF Transmitter/Receiver	\$1.46	Gearbest
Encoder	\$1.75	Jameco Electronics
AC/DC Desktop Adapter 24V 50W	\$24.13	Digikey
AC Cord (North America)	\$5.63	Digikey