Auto Brace

Walk Again

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Problem statement

Knee injury accounts for 41% of all sports injuries"; is a quote from an article published in the British Journal of Sports Medicine written by Dr. Parag Sancheti and colleagues. Described in the article are important risk factors related to a knee injury and common methods of both prevention and treatment. These include surgery and rehabilitation of the mentioned common types of injury. We see that there are many people who could benefit from a design improvement in physical therapy techniques that offers a portable and effective option to existing technologies such as CPM machines

Design parameters

House of Quality

Priority relative weight %	Customer priority Weight	Improvement direction	v	^	^	^	^	v	^
		Customer requirements	Weight (lbs)	Battery life (mAh)	Resitance Force (lbs)	Adjustable Sizing	Data Transmission	Cost	Material Strength
11.10%	3	Portable	9	9	3	9	3	3	3
11.10%	3	Lightweight	9	3	3	3	0	3	9
18.50%	5	Safety	3	3	9	9	0	3	9
18.50%	5	Range of Motion Training	3	9	9	3	0	9	3
18.50%	5	Strength Training	3	9	9	3	0	9	9
14.80%	4	Modularity	1	3	3	9	0	3	3
7.41%	2	Network Capabilities	0	9		1	9	9	0
Total=100	Total=27	Importance Rating	381.1	632.79	610.5	551.31	99.99	566.19	566.1
		Importantace Raing %	11.20%	18.60%	17.90%	16.20%	2.90%	16.60%	16.60%

Correlation Matrix

Weight							
Battery Life	(- -)						
Resistance Force	(-)	(+)					
Adjustable Sizing	(-)						
Data Transmission		(+)					
Cost	(+ +)	(- -)	(- -)	(-)	(- -)		
Material Strength	(- -)		(+)			(- -)	
Engineering Requirements	Weight	Battery Life	Resistance Force	Adjustable Sizing	Data Transmission	Cost	Material Strength
Improvement direction	v	^	^	^	^	v	^

Pugh Chat

Knee PT Device

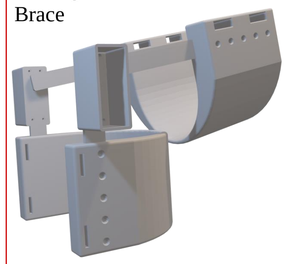
		Concepts		
Selection Criteria	**CPM Machine**	**1**	**2**	**3**
Weight		+	+	+
Cost		+	+	+
Range of Motion Trainir	D	-	-	+
Strength Training	A	+	+	+
Power Consumption	T	+	+	S
Modularity	U	+	+	+
Portability	M	+	+	+
Safety		S	S	-
Automation		-	-	+
PT Assistance		+	S	+
# of Pluses		7	6	8
# of Minuses		2	2	1

Abstract

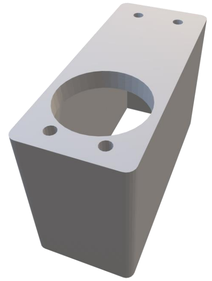
This project aims to design and develop a motorized knee brace that acts as a portable physical therapy device to improve mobility and physical therapy compliance for individuals with knee joint conditions. The research methodology involves conducting a literature review, user research, designing and prototyping the device, testing it on a sample population, and evaluating its effectiveness

Design

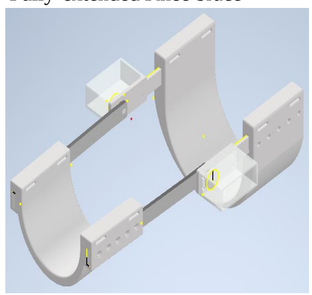
Resting Position Knee Brace



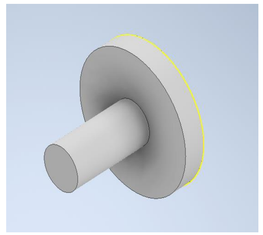
Motor Housing



Fully-extended Knee brace

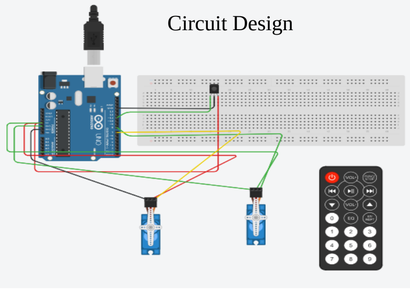


Shaft and plate piece



Control System

Circuit Design



- Infrared control, allowing 0-135° of range of motion for users
- Custom physical therapy with 1°, 5°, 10°, 30° increments and rotational speed control
- Future implications to add Bluetooth control, through a mobile app

Conclusion

An automatic and portable physical therapy device, with range of motion therapy capabilities, has been created, that is more affordable than industry-standard Continuous passive motion devices. It also achieves the goal of an ergonomic design, which accounts for both engineering and customer requirements, allowing users to have custom and wireless control over their recovery.

Bill of materials

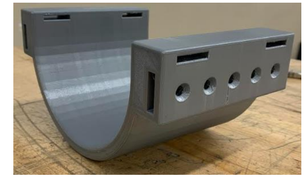
Bill of Materials

Items	Quantity	Part	Material	Description	Supplier	Product Number	Cost
1	1	Velcro Stabiltiy Straps	Velcro Strap material	Velcro Strap, Hook and Loop, 2" Wide, 10' Length	Amazon	1806-OW-PB/B-10	$13.49
2	1	Frame and Motion Supports	Aluminum Flat Bar	1/4"X 2" Square Aluminum Flat Bar-12"Long 6061 Aluminum Bar	Amazon		$21.95
3	2	Frame and body of PT device	Polycarbonate filament	Polymaker Tough PC Filament	Amazon	PA02001	
4	2	Motor	High torque DC Motor	150 kg-cm DC motor	amazon	A58SW31ZY or B0B7DRQRRQ	$180
5	2	Battery Pack for motors and arduino	9 volt battery pack	USB Rechargeable 9V Battery: 480mAh	Amazon	B0B6W9RXW2	
6	1	Program Chip for strength and range of motion training	Arduino	Arduino UNO REV3	Amazon	A000066	
7	2	Servo Disks	Metal	ERGFV Drone Parts for RC,18T Metal Servo Arm/Servo Disc	Amazon		$32.00
8	1	Bluetooth Module	Electronics	DSD TECH HC-05 Bluetooth Serial Pass-through Module	Amazon		$10.00
9	1	Mounting screws-calf	Aluminum	1 pack of 25 screws ¼ inch- 20 thread size, 0.5 inches long	McMaster-Carr	99468A188	$13.90
10	1	Mounting screws-thigh	Aluminum	1 pack of 25 screws ¼ inches-20 Thread size, 0.5 inches long	McMaster-Carr	99468A161	$6.67
11	1	Thigh supports	Aluminum	1 piece of Easy-to-Form Marine-Grade 5086 Aluminum 2 inches wide by 24 inches long, by ¼ inches thick	McMaster-Carr	5865T74	$21.83
12	1	Velcro Stabiltiy Straps	Velcro strap material	Securing Straps Adjustable Nylon Hook and Loop Cinch Cable Ties Down with Metal Buckle	Amazon	SS19VG310	$12.89
13	1	Mounting screws-thigh	Aluminum	1/4"-20 Thread Size, 1" Long	McMaster-Carr	99468A195	$20.79
						Total	$333.52

Manufacturing

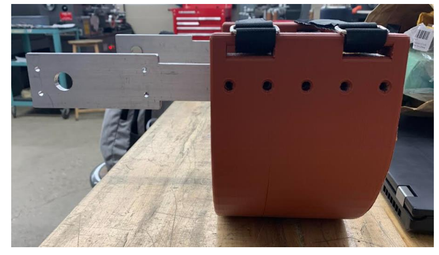
Thigh support

Calf Clamp



Shaft piece

Thigh Clamp



- Thigh and calf clamps were 3D printed using PLA, and motor housing using ABS
- Marine – Grade 5086 Aluminum, thigh supports were milled
- Aluminum shaft piece was machined on a lathe
- Circuit wires were soldered together on an Arduino Nano microcontroller and powered with a 24V battery source