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# Final Product Testing Proof

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BIOM PROSTHESIS ADAPTER 18F01

## PYLON

### Test 1:

Measure maximum and minimum height adjustment of the pylon using a tape measure.

### Test 1 Result:

As a customer requirement of the height adjustability to an average human shank length, the pylon ranged from 23 cm to 36 cm. Adding the BiOM foot height to the total length of the device would add 20 cm more. The average male height in the United States is 5'9" and 5'4" for females, knowing that the adapter would exceed both averages.



Figure 1: Pylon at short state



Figure 2: Pylon at longest State

### Test 2:

- i. Start Treadmill system to measure force applied to the pylon.
- ii. Extend pylon 2 inches and clamp it.
- iii. Place flat surface over bottom of pylon.
- iv. Apply sudden force over top of pylon until it buckles/clamp slips to determine factor of safety.

### Test 2 Result:

Since the Team had access to Nishikawa Biomechanics Laboratory, the team used a treadmill force sensors to determine the factor of safety. One of the team members have had to ask for an approval and instructions on how to operate the treadmill in order to collect data of force applied to the pylon. The pylon slipped while applying 175 lbs, that is a team member carrying two bags loaded with heavy books.



Figure 3: Team member applying force to pylon

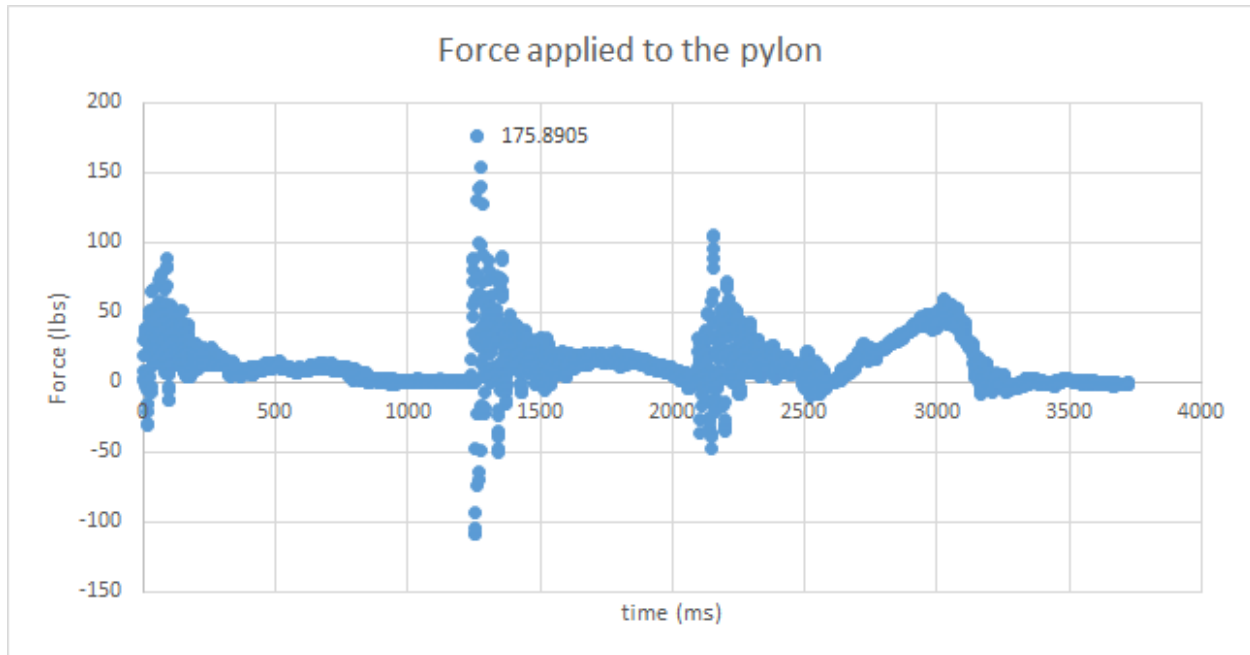


Figure 4: Data for pylon testing. Force vs time graph

## ATTACHMENT

To test the U-bar attachment, a similar procedure to the pylon test was used. The U-bar was attached to the pylon and force was applied in the axial to the two sides of the U-bar on the treadmill force sensors as seen above in Figure 3. The goal of this test was to determine the force required to break the U-bar.

Based on testing, the pylon slipped before the U-bar broke. Just testing the U-bar with the upper pylon, the team was unable to apply enough force to cause the U-bar to break.

## LEG SUPPORT

### Test 1:

- i. Get 10 volunteers with no background of project. Have volunteers secure leg support without the attached pylon to their leg.
- ii. Volunteers will stand and put their weight on their bent knee while it is resting on a chair.
- iii. The volunteers will rate the comfortableness of the support from 0 to 10, 10 being very comfortable, 0 being unbearable pain.
- iv. Determine the average time of attachment to the user's leg for someone unfamiliar with the system.
- v. The device must have an average of 8/10 comfortability rating for the 10 volunteers to pass the comfortability test.

### Test 1 Result:

Ten volunteers with no background of the project have participated to rate the device comfortability. The team explained the project and showed the volunteers how to wear the device safely. Next, a team member timed each person while putting on the device which was an average of 19.11sec. Finally, the device obtained a rating of an average of 8.3/10, being ten as its very comfortable and zero as unbearable pain. A summary of this result is provided below;

Table 1: Results of the 10 volunteers

volunteers	Time (s)	comfortability rating (0-10)
1	28.7	7
2	12.9	7
3	16.2	9
4	20	9
5	14.2	9
6	23	9
7	23.6	8
8	17.2	8
9	19.9	9
10	15.4	8
<b>AVERAGE</b>	<b>19.11</b>	<b>8.3</b>



Figure 5: Volunteer wearing the device

**Test 2:**

Width adjustable:

Thigh cuff circumference: minimum = 53.5 cm; maximum = 68.5 cm

Calf cuff circumference: minimum = 40.3 cm; maximum = 46.5 cm



Figure 6: Measuring the minimum and maximum circumference

## SYSTEM

### Test 1:

Final cost of final product < \$1000?

The final cost of the final product is calculated as \$313 which satisfies our customer requirements.

Table 2: Final product cost

Parts	Quantity	Cost
Bike Clamp	1	\$7.99
Compression Spring	1	\$3.53
Carbon Fiber Sticker	1 roll	\$8.52
Shoulder Bolts	2	\$5.04
Lock Nuts	2	\$2.03
Small Compression Springs	6	\$6.70
Chicago Bolts	6	\$11.20
Comfortability Foam	3 Pcs	\$6.80
Velcro Straps	2	\$5.91
Thermoplastic Cuffs	3 sheets	\$9.70
Bearings	2	\$66.84
Pylon Attachment	1	\$14.99
Carbon Fiber Upper Pylon	1	\$12.50
Carbon Fiber Lower Pylon	1	\$13.75
Galvanize Sheet	-	\$2.39
Prepreg Carbon Fiber	4 square feet units	\$135.16
	<b>Total</b>	<b>313.05</b>

### Test 2:

Use system continuously for 2 hours to determine durability:

As the team finished the project after completing all the testing procedures, the team sent an email to Kiisa Nishikawa the owner of the BiOM and asked her if we could have access to the BiOM to use the system for a decent amount of time to prove its success. Although, due to schedule conflict the meeting was delayed until April 15th so that all team members are present with the attendance of the client.

### Test 3:

Entire system weight < 4 kg?

After fully assembling the system the device was weighted on a sensitive scale and have been measured. The full device has weighted 1.7 kg which is close to the initial customer requirement, which was 1kg after it have been raised to 4 kg.

## **Conclusion**

Based off the above testing results, it was determined that the system is to be used for someone who weighs no more than 175 lbs, must be less than 6'2" and greater than 5' in height. Calf, knee, thigh cuffs, and the U-bar can be changed out to fit someone with a smaller leg.



## APPENDIX: Bill of Materials

Part #	Part Name	Vendor	Description/Dimensions	Function	qty	cost/qty	overall cost
1.1	Aluminum Upper Pylon	McMaster-Carr	General Purpose Aluminum Tubing 31.75 mm OD, 1.651 mm Wall Thickness	Support weight	1	\$26.38	\$26.38
1.1	Carbon Fiber Upper Pylon	Rock West Composites	TUBE - ROUND - INFINITUBETW - STANDARD MODULUS - TWILL - SIZE 4 - 31.75 X 33.884 X 609.6 mm	Support weight	1	\$54.99	\$54.99
1.2	Aluminum Lower Pylon	McMaster-Carr	General Purpose Aluminum Tubing 34.925 mm OD, 1.473 mm Wall Thickness	Support weight	1	\$34.81	\$34.81
1.2	Carbon Fiber Lower Pylon	Rock West Composites	TUBE - ROUND - INFINITUBETW - STANDARD MODULUS - TWILL - SIZE 3 - 27.965 X 30.099 X 609.6 mm	Support weight	1	\$49.99	\$49.99
2.1	L-Shaped Leg Support	Rock West Composites	Prepreg carbon fiber Toray T300 3K twill weave 250F resin 1003.3 mm wide x 0.279 mm thick	Frame support	5 - 4 sqft. units	\$33.79	\$168.95
2.2	Telescoping Attachment	Rock West Composites	CARBONNECT - MOUNTING PLATE KIT - ALUMINUM - FOR 25.4 mm ID ROUND TUBING	Hold system together	1	\$14.99	\$14.99
2.5	Bearings	McMaster-Carr	bearings: High-Load Sealed Ball Bearing with shaft diameter of 12.7 mm and OD of 44.45 mm	Allows Smooth Rotation	2	\$33.42	\$66.84
3	Cuffs	Plastics 2000	Kydex V Sheet 304.8 mm x 304.8 mm 2.997 mm thick	Leg Support	2	\$3.60	\$7.20
3	Cuffs	Plastics 2000	Kydex V Sheet 304.8 mm x 304.8 mm 2.362 mm thick	Leg Support	2	\$3.30	\$6.60
3	Cuffs	Plastics 2000	Kydex V Sheet 304.8 mm x 304.8 mm 2.032 mm thick	Leg Support	2	\$3.10	\$6.20

3	Cuffs	Plastics 2000	Kydex V Sheet 304.8 mm x 304.8 mm 1.524 mm thick	Leg Support	2	\$2.80	\$5.60
3.3	Velcro Straps	Amazon	609.6 mm x 50.8 mm Cinch Straps - 5 Pack	Leg Support	1	\$14.78	\$14.78
3.5	Foam	Amazon	Neoprene Sponge Foam Rubber Roll with Adhesive 381 mm x 1524 mm x 3.175 mm	Comfortability	1	\$13.80	\$13.80
3.5	Foam	Amazon	Neoprene Sponge Foam Rubber Roll with Adhesive 381 mm x 1524 mm x 6.35 mm	Comfortability	1	\$14.80	\$14.80
4	Telescoping Clamp	Rock West Composites	TELESCOPING CLAMP - INFINITUBETW - SIZE 4	Pylon adjustment	1	\$27.99	\$27.99
4	Bike Clamp	Amazon	Gub Bike Seat Post Clamp Tube Clip Quick Release Aluminum Alloy, 34.9mm	Pylon adjustment	1	\$7.99	\$7.99
4	Bike Clamp	Amazon	ODIER Bike Bicycle Quick Release Seat Post Clamp 34.9mm 31.8mm MTB Bike Road Bike Casual Bike Seat Post Clamp	Pylon adjustment	1	\$8.29	\$8.29
5.1	Small Compression Springs	McMaster-Carr	smaller compression spring: Length of 14.986 mm, OD of 17.043 mm and ID of 13.386 mm	Secure Calf	1 pkg	\$6.70	\$6.70
5.3	Compression Spring	McMaster-Carr	302 Stainless Steel Corrosion-Resistant Compression Springs 5" Long, 1.219" OD, 0.939" ID	Allows the pylon to move forward	1	\$3.53	\$3.53
6.1	Chicago Bolts	McMaster-Carr	Steel Low-Profile Binding Barrels and Screws 8-32 Thread Size, for 3.175 mm - 4.763 mm Material Thickness	Hold system together	1 pkg	\$10.68	\$10.68
6.1	Chicago Bolts	McMaster-Carr	Steel Low-Profile Binding Barrels and Screws 8-32 Thread Size, for 4.763 mm - 6.35 mm Material Thickness	Hold system together	1 pkg	\$11.48	\$11.48
6.1	Chicago Bolts	McMaster-Carr	Steel Low-Profile Binding Barrels and Screws 8-32 Thread Size, for 19.05 mm - 25.4 mm Material Thickness	Hold system together	1 pkg	\$11.20	\$11.20

6.1	Chicago Bolts	McMaster-Carr	Steel Low-Profile Binding Barrels and Screws 8-32 Thread Size, for 6.35 mm - 9.525 mm Material Thickness	Hold system together	1 pkg	\$11.61	\$11.61
6.2	Shoulder Bolts	McMaster-Carr	shoulder bolts: Alloy Steel Shoulder Screws 12.7 mm OD and 25.4 mm long. Thread size of 9.525 mm -16	Hold system together	4	\$2.52	\$10.08
2.2.1	Attachment Screws	McMaster-Carr	Alloy Steel Low-Profile Socket Head Screw Black-Oxide, 6-32 Thread Size, 12.7 mm Long	Hold system together	1 pkg	\$9.63	\$9.63
6.2.1	Locknuts	McMaster-Carr	Locknuts: 6061 aluminum thread size of 9.525 mm -16	Hold system together	1 pkg	\$4.06	\$4.06
	Compression Spring	McMaster-Carr	Spring-Tempered Steel Compression Spring 254 mm Long, 73.812 mm OD, 59.538 mm ID	Allows the pylon to move forward	1	\$19.09	\$19.09
	Vacuum Bag Sealant Tape	Rock West Composites	Vacuum bag sealant tape 12.7mm x 9.144 m roll	Close the oven bags	1	\$9.99	\$9.99
	Oven Bags	Amazon	Reynolds Oven Bags, Large, 5 ct	Carbon Fiber Lay-up	1	\$8.44	\$8.44
	Disposable Suit	Amazon	Disposable Suit	Protection	1	\$7.45	\$7.45
	Vinyl Gloves	Amazon	Vinyl Gloves	Protection	1	\$6.45	\$6.45
	Zinc-Galvanized Sheet	McMaster-Carr	Zinc-Galvanized Low-Carbon Steel Sheet 609.6 x 1219.2 x 0.483 mm	To Form the Carbon Fiber	1	\$19.17	\$19.17
	Carbon Fiber Sticker Film	Amazon	304.8 x 1524 mm 4D Carbon Fiber Black Vinyl Vehicle Wrapping Sticker Film	Provides nice appearance	1	\$8.52	\$8.52
	Compression Spring	McMaster-Carr	302 Stainless Steel Corrosion-Resistant Compression Springs 5" Long, 0.875" OD, 0.635" ID	Allows the pylon to move forward	1	\$3.25	\$3.25
	Compression Spring	McMaster-Carr	Compression Spring 6" Long, 0.875" OD, 0.635" ID	Allows the pylon to move forward	1	\$12.99	\$12.99
	Compression Spring	McMaster-Carr	302 Stainless Steel Corrosion-Resistant Compression Springs 5" Long, 0.75" OD, 0.54" ID	Allows the pylon to move forward	1	\$11.63	\$11.63

Elastic Band	Amazon	Resistance Loop Exercise Bands	Allows the pylon to move forward	1	\$10.95	\$10.95
Aluminum Sheet	McMaster-Carr	6061 Aluminum Sheet 2.032 mm Thick, 304.8 x 304.8 mm	To Form the Carbon Fiber	1	\$18.36	\$18.36
					<b>Total</b>	<b>\$745.46</b>
					<b>Tax &amp; Shipping</b>	<b>\$273.74</b>
					<b>Sub Total</b>	<b>\$1,019.20</b>