

Re-Designing Support Systems For The Prophylactic Knee Brace

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Introduction

Overall, the goal of this project was to re-design the support system of the M-202 Protective Knee Guard by McDavid. This off-the-shelf prophylactic knee brace is designed to reduce the frequency and severity of knee injuries by supporting the collateral ligaments during high-risk athletic activities such as football. More specifically, it restricts severe valgus and varus angulations thus protecting the MCL and LCL respectively. While the M-202 Protective knee Guard is capable offering this type of protection, repeated malfunctions of the support system that mounts the brace to the leg, cause a drastic reduction in the effectiveness and comfort of the brace.



M-202 Protective Knee Guard by McDavid

Features

- 11.8 cm wide padded, elastic neoprene straps with hook and loop fasteners.
- Straps are about 0.4 cm thick and offer around 10 cm of elastic extension
- 4.8 cm wide non-elastic strap with hook and loop fasteners on upper calve.
- Total mass of 400g, support system mass of 175g.
- Retail at about \$80 U.S. per unit, (2006 dollars).

Disadvantages

- Thick neoprene strapping slips, rotates and/or binds behind the knee.
- Slipping creates discomfort and reduces the brace's effectiveness in protecting the collateral ligaments.
- Binding behind the knee hinders athletic performance due to an impediment in knee flexion.
- Failure of hook and loop fasteners.



McDavid.com

Design Constraints

By identifying current flaws in the brace support system a list of design constraints was developed to guide development of the support system. Following these constraints prevented repeating errors made by previous manufacturers while assuring a product that would outperform the original.

1. The support system for the knee brace must be low in mass, not exceeding 200 g.
2. When fully saturated, the weight of the support system must not increase by more than 2.5 times its original weight.
3. Vertical slippage must not exceed 5 mm during testing.
4. Rotational slippage must not exceed 5 mm during testing.
5. The bracing system must not reduce free knee flexion by more than 15%.
6. The support system must be form-fitting and adjustable to the majority of individuals whom will use it.
7. The brace must have the ability to be quickly and easily attached and detached from the leg.
8. The production cost of the support system must be comparable to that of the M-202 Protective Knee Guard by McDavid.



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Kneequest.com

Conceptual Designs

Dual Strap Support System

- Two 1-1/2" wide nylon straps with D-rings and hook and loop fasteners.



- Large elastic loop to hold the brace across middle section of strap.



Compression Sleeve Support System

- Compression sleeve shrouds the brace with spaces around knee cut out.



- Elastic cuffs

- One 1-1/2" wide nylon strap with D-ring and hook and loop fasteners.

Shorts/Girdle Support System

- Shorts or girdle suspends brace from waste band with adjustable 1" nylon strap and plastic duckbill buckle.

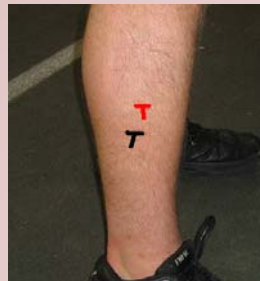


- Two 1-1/2" wide nylon straps with D-rings and hook and loop fasteners.

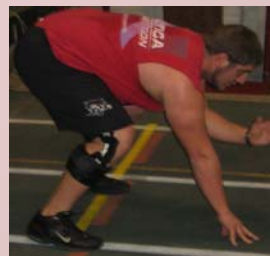
- Can be used with one or two suspension straps.

Experimental Testing and Results

Each prototype and the original M-202 Protective Knee Guard were then worn during a rigorous workout which was designed to mimic typical athletic motions of an offensive lineman in football. The workout was broken up into three stages to concentrate on: straight ahead motion, lateral motion and change in direction, and explosive movements and offensive lineman techniques.



Lower leg brace displacement markings from workout.



Simulating lineman techniques during workout.

Test	Brace Support System					
	M-202 Protective Knee Guard by McDavid	Dual Strap	Compression Sleeve	Shorts/ Girdle with one strap	Shorts/ Girdle with two straps	None
Dry mass (g)	175.5	140.5	118.7	291.8	319.8	-
Saturated mass (g)	408.5	199.0	267.6	613.8	660.3	-
Saturation ratio	2.33	1.42	2.25	2.10	2.06	-
Free Knee Flexion (°)	81	96	93	96	95	106
Reduction in flexion	24%	9.4%	12%	9.4%	10%	-
Rotational slip (mm)	Upper 48 Lower -10	Upper 21 Lower 0	Upper 0 Lower 0	Upper 10 Lower 3	Upper 10 Lower 8	-
Vertical slip (mm)	Upper -59 Lower -35	Upper -12 Lower -6	Upper -10 Lower -14	Upper 3 Lower 9	Upper 3 Lower 7	-
Mag of Dis (mm)	Upper 76 Lower 36	Upper 16 Lower 22	Upper 10 Lower 14	Upper 10 Lower 9	Upper 4 Lower 11	-
Comfort level (1-5)	3	4	2	3	4	-
Visible effect (1-5)	2	4	1	3	4	-

Scale: 1 good; 5 bad
Mass of shorts: 110g
Top performers noted by highlighting.

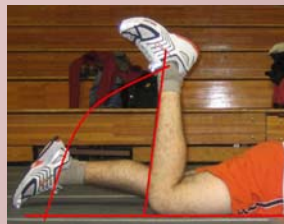
Final Design and Performance

The Evolution Knee Guardian

- Shorts or girdle suspends brace from waste band with adjustable 1" nylon strap and plastic duckbill buckle.

- Compression sleeve shrouds the brace with spaces around knee cut out and elastic cuffs.

- Two 2" wide nylon straps with D-rings and hook and loop fasteners.



Measuring free knee flexion.

Test	Brace Support System		
	M-202 Protective Knee Guard by McDavid	The Evolution Knee Guardian	None
Dry mass (g)	175.5	291.4	-
Saturated mass (g)	408.5	669.7	-
Saturation ratio	2.33	2.30	-
Free Knee Flexion (°)	78	95	106
Reduction in flexion	26%	10%	-
Rotational slip (mm)	Upper 11 Lower -16	Upper -2 Lower 0	-
Vertical slip (mm)	Upper -36 Lower -27	Upper 0 Lower 0	-
Mag of Dis (mm)	Upper 38 Lower 31	Upper 2 Lower 0	-
Comfort level (1-5)	2	1	-
Visible effect (1-5)	2	2	-

Scale: 1 good; 5 bad
Mass of shorts: 110g

Conclusion

The Evolution Knee Guardian was able to meet and exceed all of the design constraints. Its performance and comfort is greatly improved over the original McDavid design and it has the ability to properly adjust to fit many unique individuals. Using this device will result in much improved protection to the collateral ligaments when playing football at high-risk positions.



Acknowledgements

Cheryl Rockwood; Stephen Hughes; Stanley Gorski; Matthew Roginski; Clint King; Union College's Internal Education Fund