IPRO 332
Tournitech

Smart clothing for sensing muscle development

Purpose

- To design and prototype a device that will help build arm/leg muscles in a short period of time
- Investigate possible target markets

Background

- People usually exercise in post absorbent state
- Glucose is the primary fuel source while exercising
- Glucose:
  - Aerobic (oxygen present)
  - Anaerobic (no oxygen present)

Background

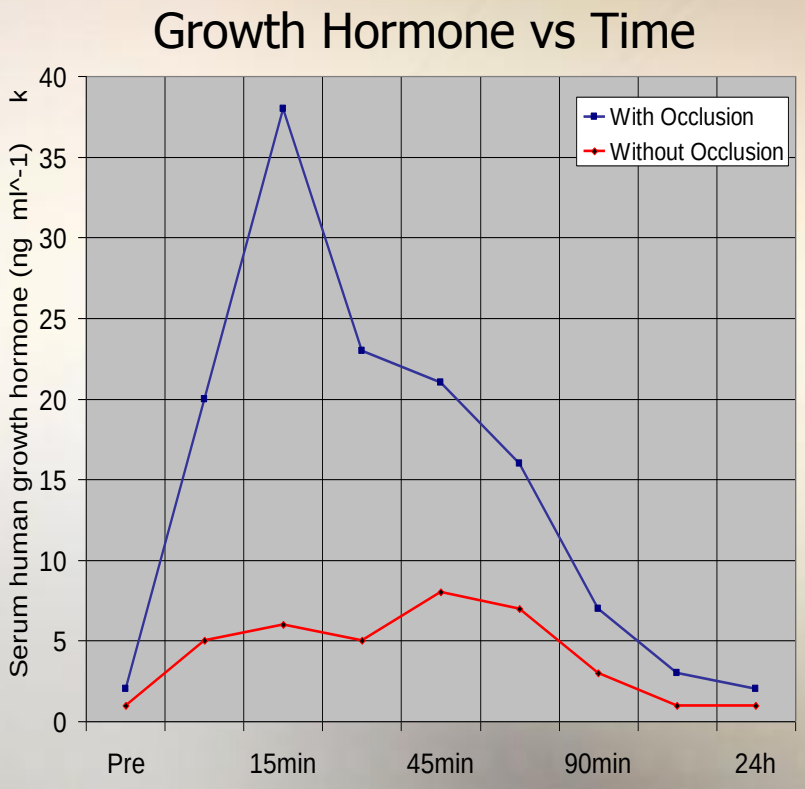
- Working muscles call upon muscle fibers in an order of smallest to largest
- Fast twitch muscles (anaerobic) make individuals stronger and faster
- Less oxygen available to the legs and arms - the slow twitch muscles fatigue faster leaving the fast twitch muscles to work alone

Concept

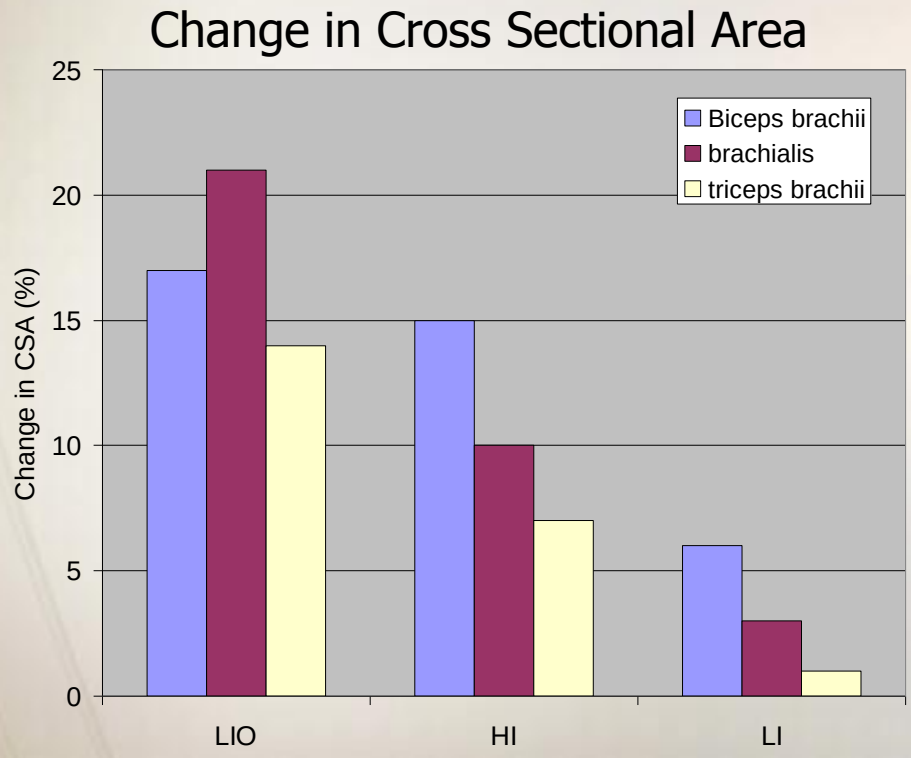
- Tourniquet- device that restricts blood flow on the arms and legs, which diminishes the level of oxygen available
- Glucose- metabolized to lactic acid, which splits into lactate ion and hydrogen ion
- Hydrogen ion- the acid in the lactic acid which causes pH to decrease

Advantages

- Growth hormone, norepinephrine, and lactate consistently showed marked, transient increases after the exercise with occlusion.
- This suggests that using a low-intensity with restriction workout has the same benefits as a high intensity without restriction workout.
- The concentrations dramatically increased after the exercise with occlusion.



Advantages cont.

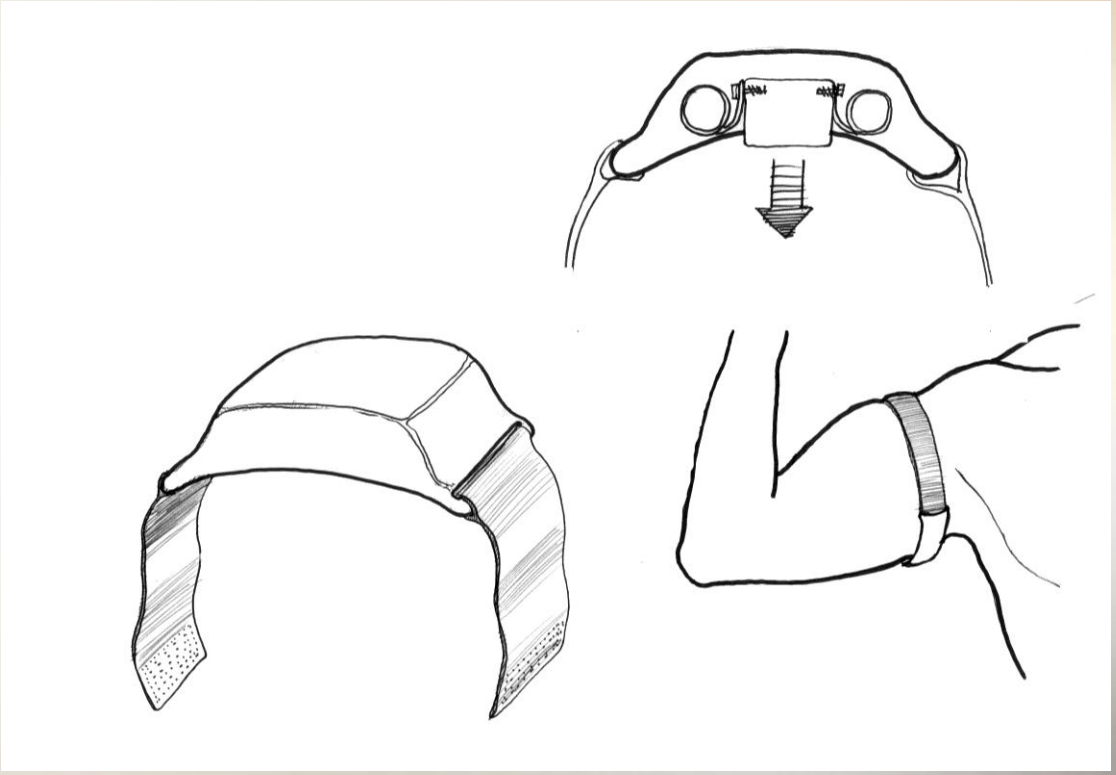


- Resistance exercise combined with vascular occlusion, even at an extremely low intensity, causes enhanced muscular electrical activity and endocrine responses.
- Occlusion causes the activation of a sufficient number of fast-twitch fibers.
- Training during moderate restriction of blood flow is effective in rehabilitation after ACL reconstruction.

Design

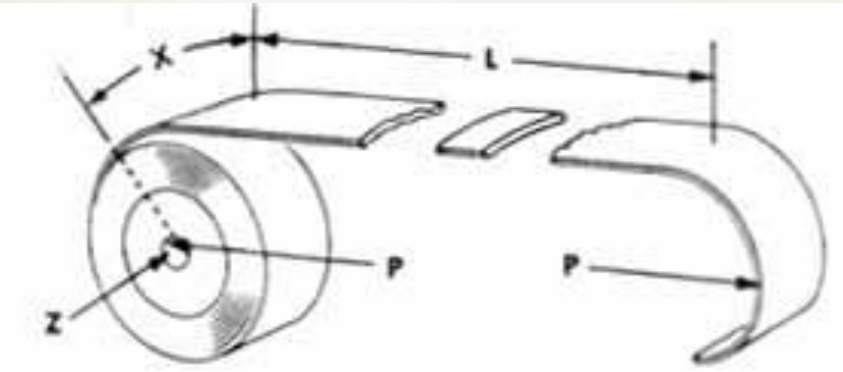
Cuff Parameter	Arm	Leg
Width	90 mm	33 mm
Length	700 mm	800 mm
Pressure	100 mmHg	180 mm Hg
Time	15 min	15 min
Location	Proximal end of the arm	Proximal part of the thigh

Mechanical Design



Mechanical Design
(the constant force spring)

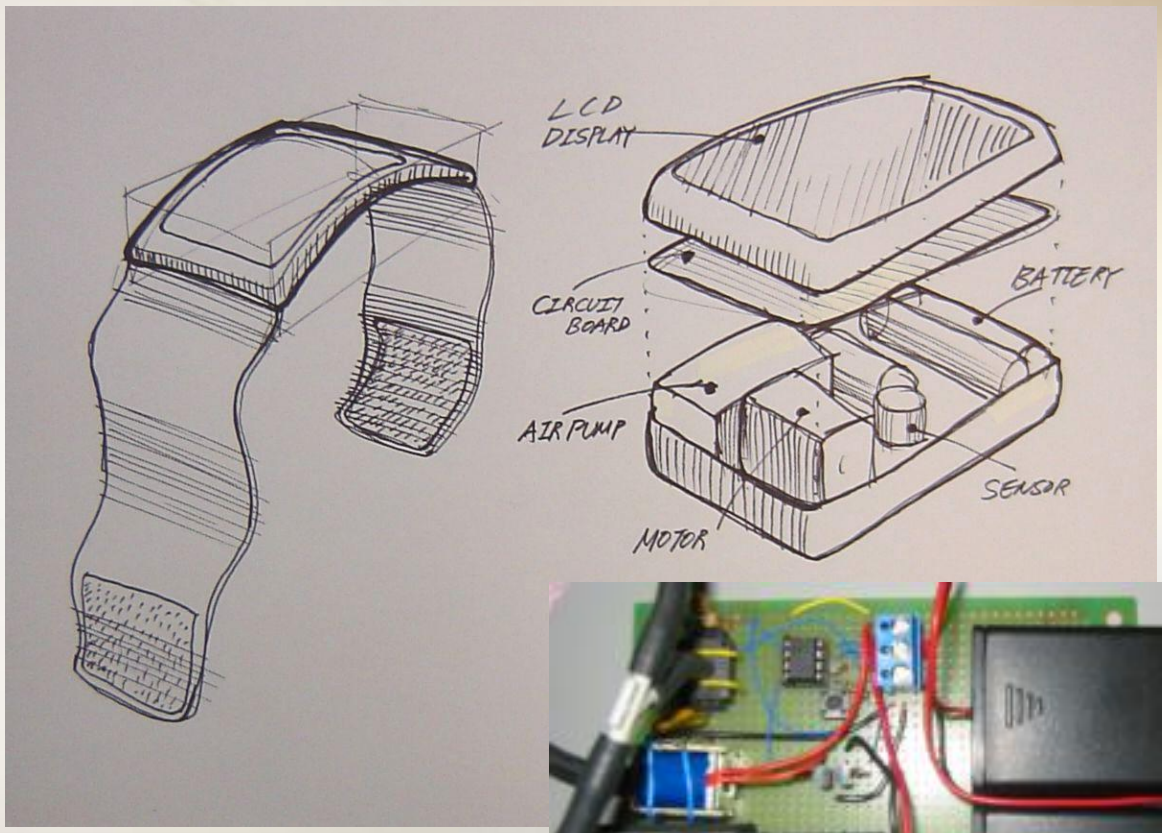
- Constant resisting force *P*
- Force *P* does not increase with increasing extension *L.*

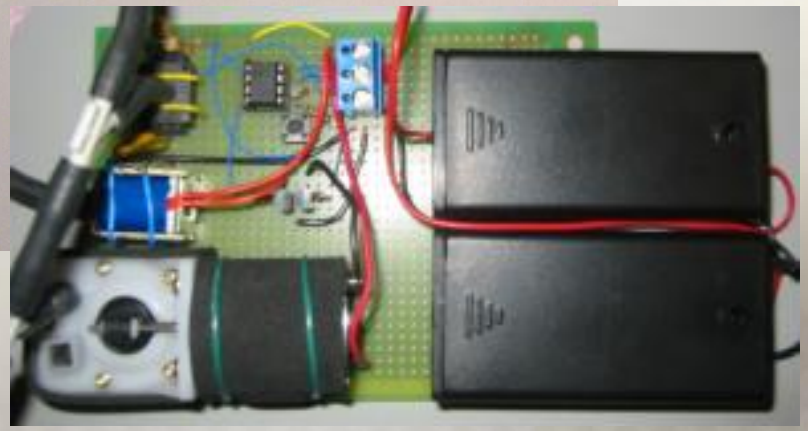


Mechanical Design
(Final Design)

- Constant force spring attached to a 2 square inch block, placed over the artery, and attached to adjustable strap
- 4 lbs of force
- Constant pressure of approx. 2 psi.
- Block locked in place then strapped to arm
- Block released with switch
- Constant pressure until strap released

Electronic Design





Electronic Design
Overview

- Method of Blood Restriction: Air Filled Bladder
- Bladder provides constant blood restriction
- Microprocessor controls inflation/deflation
- Monitors pressure and elapsed time
- Adjustments are made automatically
- Critical for safety requirements

Electronic Design
Further Developments

- Pulse Sensor
- Smaller Bladder
  - Smaller Pump / Battery
- pH Sensor
- Customizable

Advantages / Disadvantages

	Electrical	**Mechanical**
Economic	×	√
Simple	×	√
Easy Operation	√	√
Self Monitoring	√	×
Safe	√	×
Miniaturizable	√	×
Self Adjusting	√	√

Conclusion

- Selected Design – Electrical
  - Safety is most important
- Selected Market – Rehabilitation patients & elderly

Unanswered Questions

- What are the possible effects on the circulation including thrombosis and edema?
- PH levels produced during exercise?
- If product can be marketed to general public?
  - Alleviate pain and discomfort

Our Team

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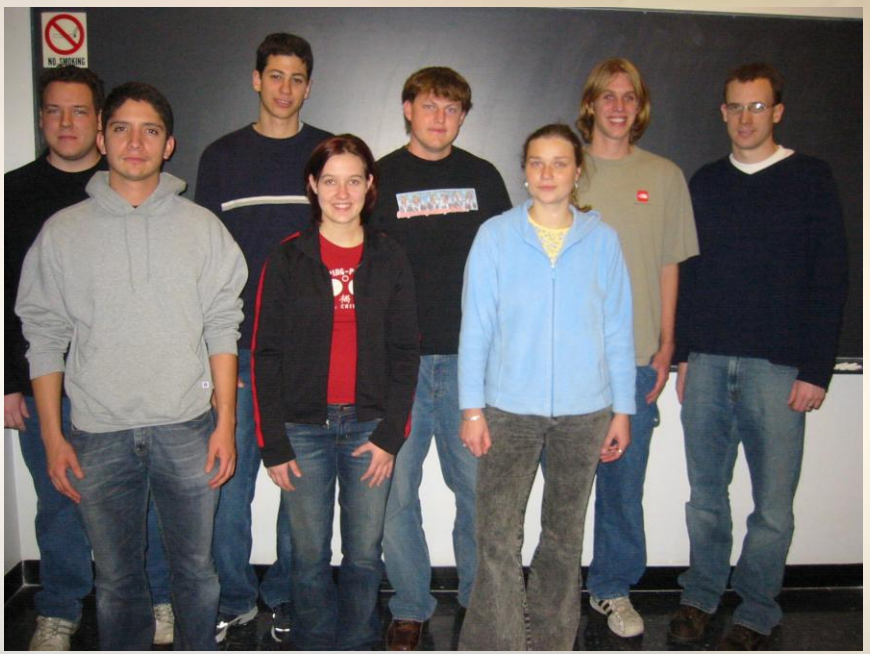
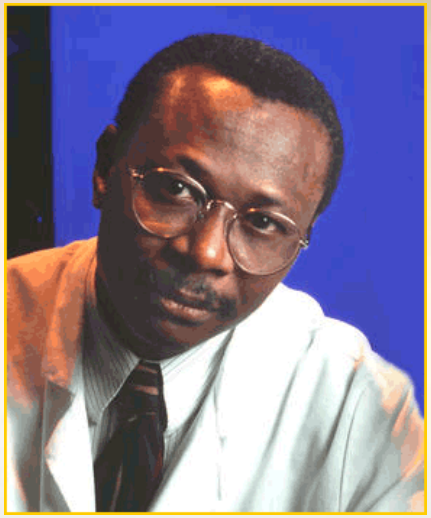


Acknowledgements

- Dr. Emmanuel Opara, Project Advisor



- Dr. Raymond Deboth, Consultant

References

- **Takarad, Y., Takazawa, H., Sato, Y., Takebayashi, S., Tanaka, Y., Ishii, N.,** Effects of resistance exercise combined with moderate vascular occlusion on muscular function in humans. *J. Appl Physiol.* 88:2097-2106, 2000.
- **Takarad, Y., Yutaka, N., Aruga, S., Onda, T., Miyazaki, S., Ishii, N.,** Rapid increase in plasma growth hormone after low-intensity resistance exercise with vascular occlusion. *J. Appl Physiol.* 88: 61-65, 2000.
- **Ohta, H., Kutosawa, H., Ikeda, H., Iwase, Y., Satou, N., Nakamura, S.,** Low-load resistance muscular training with moderate restriction of blood flow after anterior cruciate ligament reconstruction. *Acta Orthop Scand.* 74(1):62-68, 2003.
- **Fahey, T.**, 10 Things You Should Know About Lactic Acid: Old Myths and New Realities. http://www.cytosport.com/science/lacticacid.html 11/17/04