OVERUSE PREVENTION REHABILITATION FOR AMPUTEES

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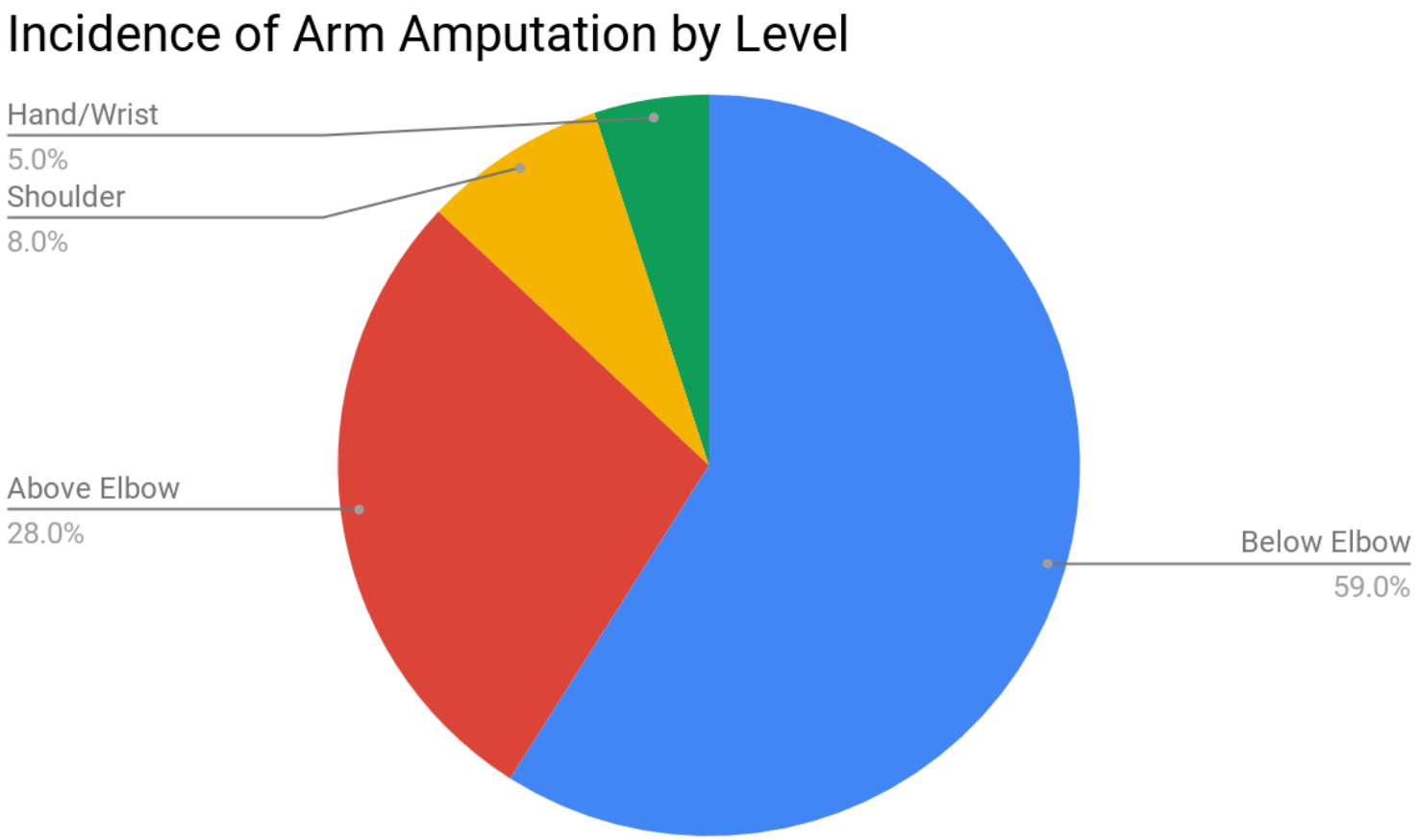
HONORS 400 THESIS DEFENSE

INTRODUCTION

- The worldwide amputee population is 3 million, with 2.4 million of them living in developing countries (LeBlanc, 2008).
  - Approximately 1.6 million in America alone (Sabzi & Taheri, 2013)
- Of all the amputations, 30% occur on an upper limb (LeBlanc, 2008).
- Males between the age of 20-40 years are the most commonly affected by upper limb loss (Bhaskaranand, Bhat & Acharya, 2003).



(Data from LeBlanc, 2008)

PROSTHETIC ABANDONMENT

- Nearly one third of persons with a limb difference are dissatisfied with their prosthetic.
  - An estimated 50% of upper limb amputees choose not to wear a prosthetic, citing issues with comfort and function (Carey et al., 2017).
- Rejection rates of those who wore prosthetics averaged 35% and 45% for myoelectric and body-powered prosthetics, respectively, in pediatric populations.
- An average of 23% (myoelectric) and 26% (body-powered) individuals rejected their prosthetics in adult populations (Biddiss & Chau, 2007).

HOW CAN WE IMPROVE PROSTHETIC OUTCOMES AND INCREASE THE QUALITY OF LIFE FOR PEOPLE USING THESE DEVICES?

PROSTHETIC TYPES

Cosmetic

(Ottobock US, 2019)

Myoelectric

(Ottobock US, 2019)

Body-powered

(Ottobock, 2013)

(Ottobock US, 2019)

COSMETIC

- Designed to look realistic
- Serves limited functional purpose
- Pros:
  - Visually appealing
  - Ability to clean the limb
  - UV & temperature resistance
- Cons:
  - Limited functionality

(Ottobock US, 2019)

MYOELECTRIC

- Leader in current prosthetic technology
- Uses a battery and an electronic system to respond to nerve signals sent by the brain
- Custom made for each user
- Pros:
  - Great advancement in science
  - Quite functional when users are trained
- Cons:
  - Expensive ($30,000-$120,000)
  - Not user friendly
  - Advancements take years to develop

BODY-POWERED

(Ottobock, 2013)

(Owen, 2017)

- Traditional models consist of a socket/interface, suspension system, harness, control cable, wrist unit and a terminal device
  - Operated by harnesses and cables moved by other parts of the body
  - Operate terminal device through voluntary opening or closing
- 'Non-traditional' 3D Printed models
  - Rigid plastic, elastic bands
  - Moves essentially the same way as traditional models
- Pros:
  - Lower cost
  - 3D prosthetics can be printed by volunteers and provided to people all over the world
  - Suit more specific needs for an individual
  - Great for children who will need multiple sizes of limbs as they grow

Cons:

- Skin irritation
- Overuse injuries
- 3D prosthetics are not fully accepted by the medical field

BODY-POWERED PROSTHETICS: MEETING THE NEEDS OF AMPUTEES

More readily available to populations in developing countries

- More affordable
- Easier to build
- Many healthcare systems in developing countries have not accessed myoelectric technology yet

Power and servicing of myoelectric prosthetics

- Myoelectric prostheses must be recharged
- Users with this type of prosthesis need to be able to reach their prosthetic provider to have it serviced in the case of repairs, updates, and adjustments

Body-powered prosthetics tend to be more:

- Durable, reliable and lower maintenance than the myoelectric models
- Offer the functionality that a cosmetic model does not

PAIN POINTS OF BODY-POWERED PROSTHETICS

(NowScienceNews, 2018)

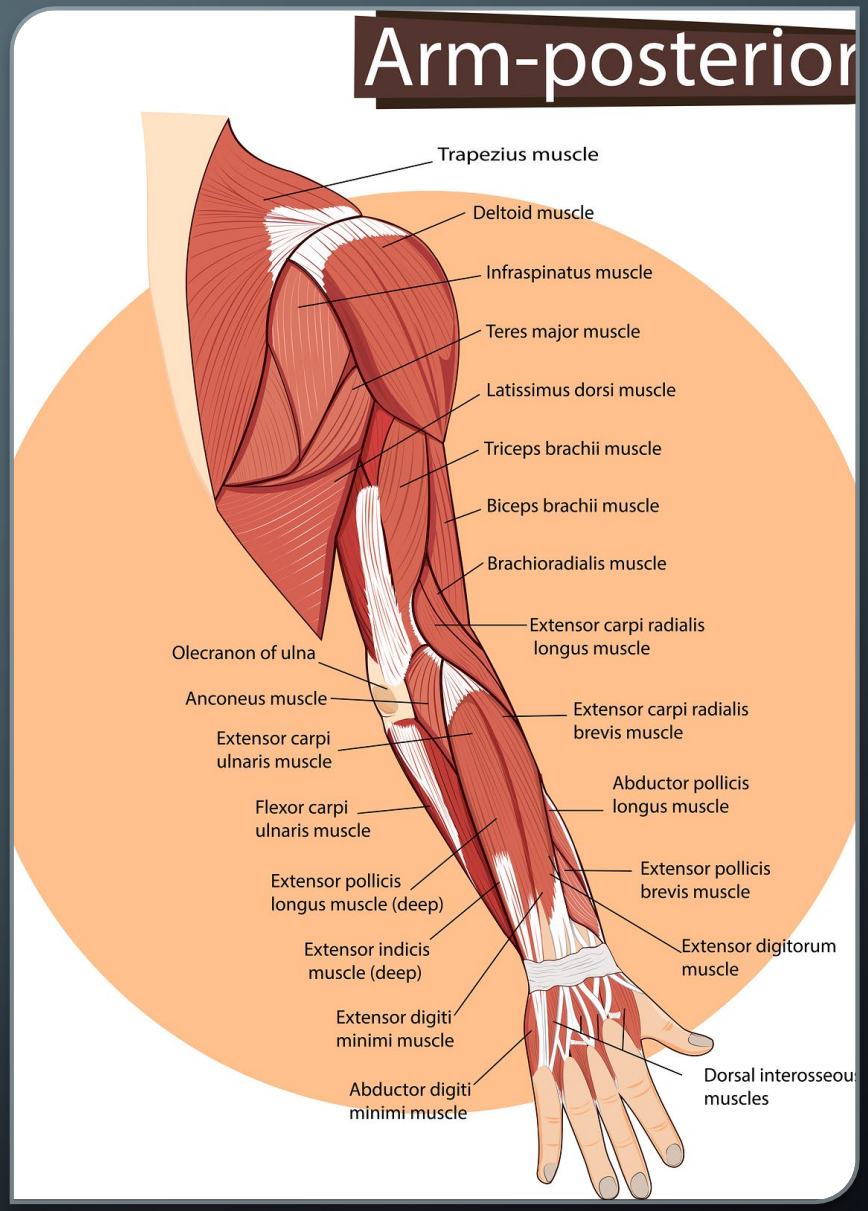
- Body-powered prosthetics have complicated harnesses and cables
  - Standard Transradial Harness
  - Shoulder saddle or heavy duty transradial harness
  - Standard Transhumeral Harness
  - Shoulder disarticulation harness
  - Bilateral Transradial Harness
- Pain, discomfort and physical changes to the rest of the body from the prolonged force placed on the residual limb caused by the harness and cable systems
  - Develop signs of overuse and overcompensation of other parts of their body

PAIN POINTS OF BODY-POWERED PROSTHETICS

- Variety of injuries associated with overuse:
  - Elevated shoulders
  - Deviated spine
  - Neck, shoulder and elbow pain
  - Carpal Tunnel Syndrome
  - Tennis elbow (epicondylitis)
  - Tenosynovitis (inflammation of synovium surrounding a tendon)
  - Shoulder impingement (repeated rubbing of connective tissues against the shoulder blade)

PAIN POINTS OF BODY-POWERED PROSTHETICS

- Common muscles injured
  - Pollicus longus and flexor tendons of the wrist
  - Abductor pollicus longus of arm
  - Rotator cuff muscles of shoulder
    - Supraspinatus
    - Infraspinatus
    - Teres minor
    - Subscapularis
- Overuse injuries become painful and debilitating if left untreated
  - Leads to prosthetic abandonment



(Jeffery, 2017)


(Scott, 2017)

PROSTHETIC ABANDONMENT

- Caused by overuse injuries and lack of user-friendly operation
- The primary reason for abandonment was a “perceived need and the prostheses available” (Ostlie et al, 2012).
- Personalized fit and function of a prosthetic and individualizing rehabilitation increased long term prosthesis use in 90.3% of participants (Ostlie et al, 2012).

SOLUTION: AT-HOME REHABILITATION PROGRAM

Strengthening the body = better control of artificial limb

Control and strength = more efficient functional use of prosthetic

Proper use of the prosthetic with strength training will prevent overuse injuries and associated discomfort

Smoother transitions between prosthetics

CURRENT REHABILITATION PROCEDURES

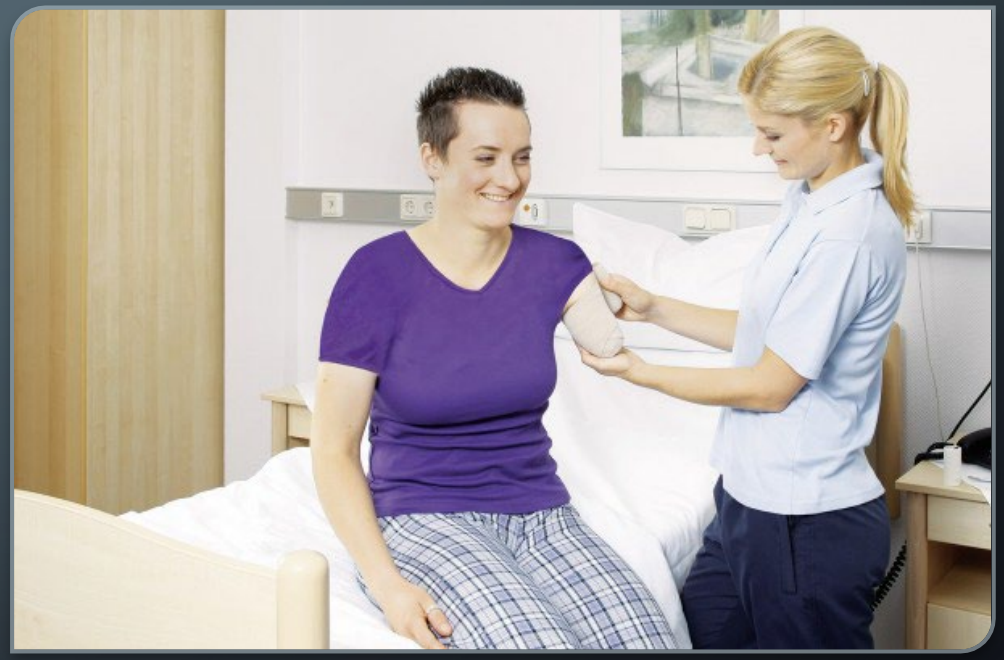
- Focus on reintegration of patient with and without prosthetic
- There is no standard for how long or how much rehabilitation a patient should have
- Structure depends on:
  - Source of limb loss (traumatic, acquired or congenital?)
  - Complexity of prosthetic
  - Functional needs
  - Motivation
  - Learning ability
- Four stages:
  - Acute postsurgical
  - Subacute pre-prosthetic training
  - Basic prosthetic training
  - Advanced long-term rehabilitation training

(Resnik et al., 2012)

STAGE ONE: ACUTE POST-SURGICAL REHABILITATION

- Begins as soon as a patient is coherent after their operation.
- No prosthetics
- Physical therapist will manipulate the patient through a series of range of motion exercises, contracture prevention, strengthening, and bed mobility.
- Progression to Activities of Daily Living (ADL's)
  - Using the bathroom
  - Dressing
  - Feeding

(Gajewski & Granville, 2006)



(Ottobock US, 2019)

STAGE TWO: SUBACUTE PRE-PROSTHETIC TRAINING

Incorporates physical therapy with pre-prosthetic training

Exercises focus on:

Core strengthening	Cardiovascular endurance	Balance exercises	All over muscular strength training

(Gajewski & Granville, 2006)

STAGE THREE: BASIC PROSTHETIC TRAINING

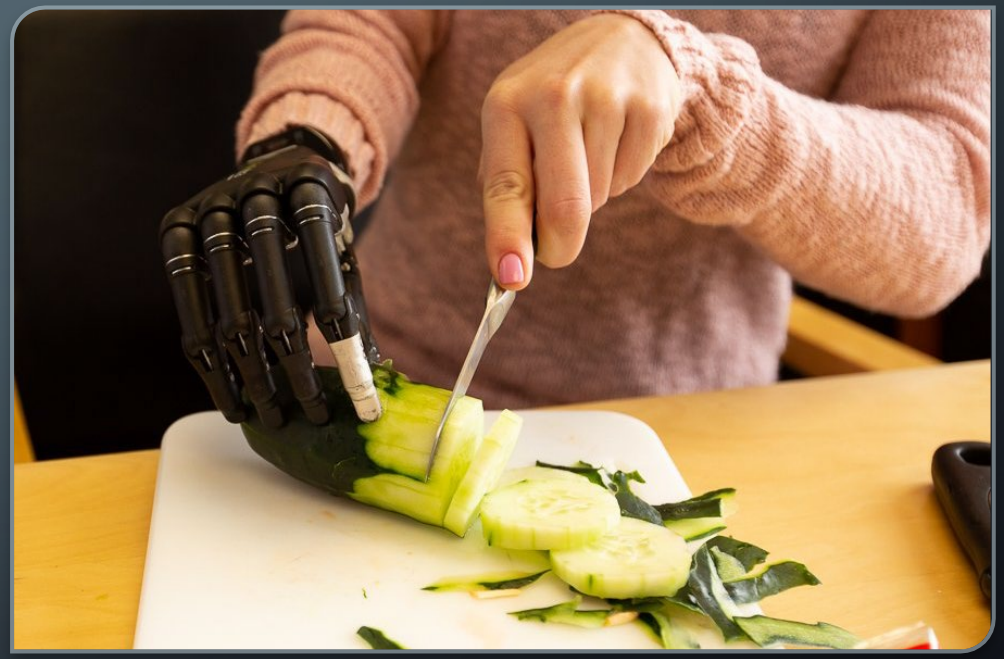
(Ottobock, 2013)

- Prosthetic fitting
- Focus on functional rehabilitation that incorporates the artificial limb
  - Strengthening exercises and pain control are crucial
  - Advances to work on fine motor skills.
- Activities of Daily Living (ADL's) return
  - Patients are trained on how to use their prosthetic to complete those activities.

(Hanger Clinic, 2019)
(Gajewski & Granville, 2006).

STAGE FOUR: ADVANCED LONG-TERM REHABILITATION

- Focus on returning the amputee back to an active lifestyle
  - Advanced skills (such as cooking, cleaning, and vocational based functions), as well as vocational evaluation and training (Gajewski & Granville, 2006).
  - Recreational sports and functional activities (i.e. cooking, doing laundry, eating, or working with money) (Resnik et al., 2012).
- Recommend visits to physical therapist at least once every one to two years after completion
  - Helps identify problems such as overuse and referred pain (Hanger Clinic, 2019).



(Henson, 2019)

WHAT'S NEXT?

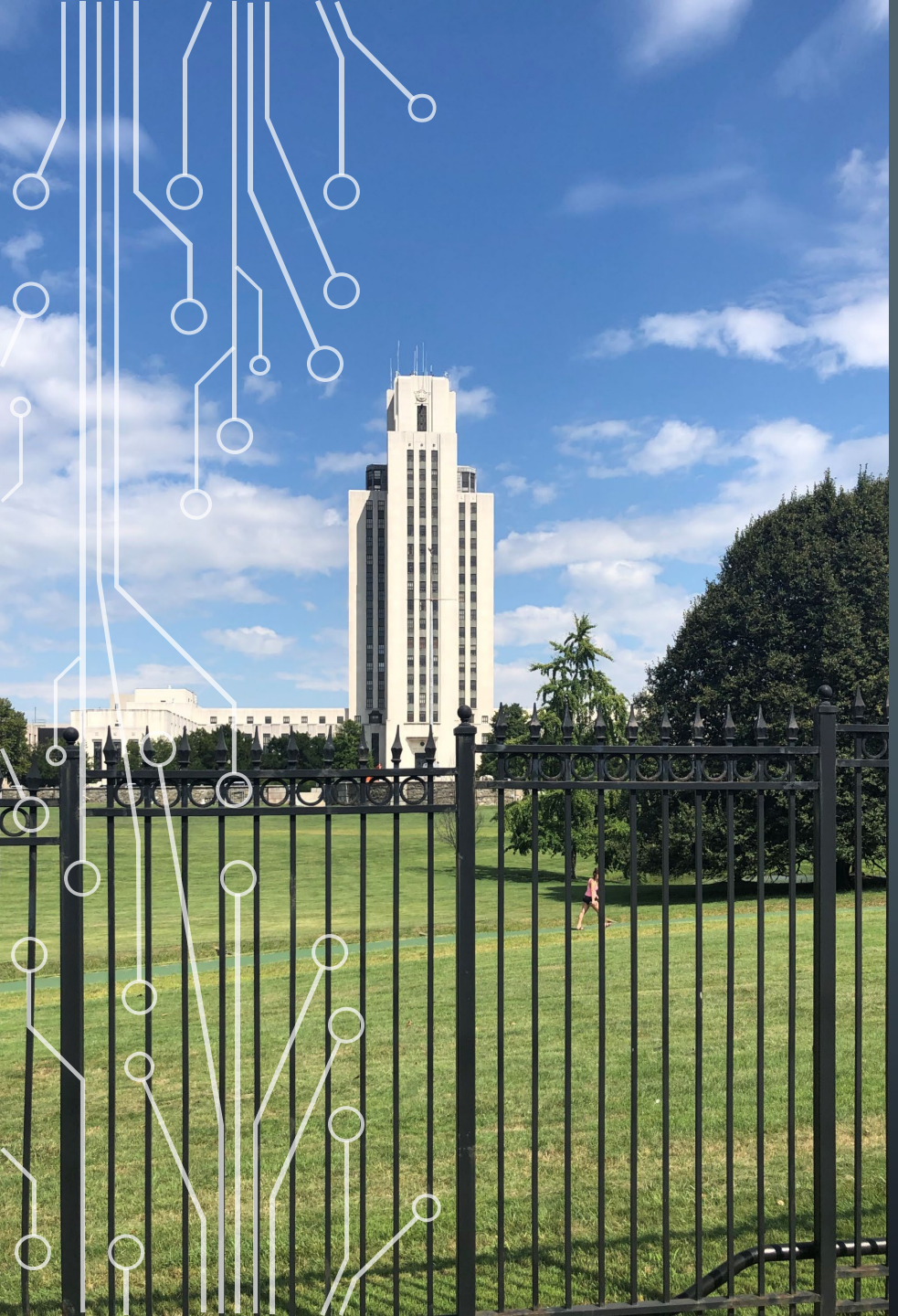
- After completion of the last stage, physical therapy stops
  - No focus on the weaknesses that may develop after integration for users of body-powered prosthetics
- Definite need for an at-home program that incorporates muscle strengthening exercises
  - Potentially will ensure longevity and strength of the body
  - Ultimately lowers the rates of prosthetic abandonment by improving comfort and functionality of the prosthetic

THE BASICS OF CREATING A PROGRAM

- A basic rehabilitation program should consist of light strengthening exercises that build up muscle over time
- Maximum of 2-3 sessions per week (American Academy of Orthopaedic Surgeons, n.d.)
- Program for upper limb amputees should focus on:
  - Scapular abductions
  - Chest expansion
  - Shoulder depression
  - Humeral flexion
  - Elbow flexion/extension
  - Forearm pronation/supination (Atkins, 1989)

PROJECTED OUTCOME

- Develop a daily at-home rehabilitation program
- Accessible through a web-based platform
  - Allows for individuals to complete rehabilitation without a physical therapist
- Avoid overuse injuries with preventative rehabilitation (ultimately lowering rates of prosthetic abandonment)



OBSERVATION

- Walter Reed National Military Medical Center
  - Operational amputee rehabilitation center
- Rehabilitation tends to last several months
- Focus on strength training
- State of the art equipment
- Patients guided through exercises by physical therapist

ARGUMENTS FOR AN OVERUSE PREVENTION PROGRAM

"Overuse injuries can be prevented by performing regular strengthening and stretching exercises targeting back and arm musculature, incorporating both limbs with or without prosthesis when applicable, and performing tasks with proper body mechanics and posture" (TIRR Memorial Hermann, 2017)

"There is currently no empirical research available to support the prevalence of overuse injuries in upper limb amputees, nor is there any research that addresses how to recognize and treat overuse symptoms before they become serious injuries in this patient population" (Gambrell, 2008).

PROGRAM STRUCTURE

- Virtual delivery- will reach a broader population
  - addresses a need for preventive rehabilitation among upper limb amputees in areas where there is a lack of access to rehabilitation professionals.
- User-friendly exercises to be completed two to three times a week for six to eight weeks.
  - The exercises will vary based on the area of the body that needs to be addressed
- Each exercise will be partnered with a clear description on how to perform the exercise and a video demonstrating proper form and technique.
- Breaking down the exercises into three categories (shoulder, elbow, wrist) will create a simple website structure for the user to navigate.

THE FINAL PRODUCT

https://sites.google.com/view/upperlimbamputeerehabilitation/home

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