Uniform Standards for the Universal Design of Fitness Equipment (UDFE)

- Beneficial Designs, Inc. – Minden, NV
  - Peter W. Axelson, M.S.M.E.
  - Seanna L. Kringen, M.S.

Why Standardization?

Assistive Technology Standards (ATS)

- Provide clinicians and consumers with objective information
- Allow government agencies to set minimum performance requirements
- Promote safe and quality products
- International standards reduce trade barriers
- Standards are under constant revisions due to changing technology

Standards Organizations

- International Standards Organization (ISO)
- Rehabilitation Engineering and Assistive Technology Society of North America (RESNA) – ANSI acredited
- ASTM

RESNA Standards Used as a Model

- RESNA Assistive Technology Standards (ATS) Committees develop standards:
  - Minimum safety criteria
  - Minimum performance criteria

RESNA ATS Board

- Oversees RESNA Standards Committees for:
  - Wheelchairs
  - Wheelchair and Related Seating
  - Wheelchairs and Transportation
  - Assistive Technologies for Persons with Visual Impairments and Hearing and Visual Impairments
  - Support Surfaces (mattress/overlay)
  - Adaptive Sports Equipment
  - Emergency Stair Travel Devises

RESNA Committees

- Consumers, organizations representing people with disabilities, researchers, practitioners, and manufacturers
- Develop objective minimum safety and performance test methods
  - Repeatable
  - Reproducible

RESNA Standards

- Based on applicable ISO Standards
- Drafted, reviewed and voted on for committee approval
  - 2/3 vote for approval
- Funded in part by:
  - PVA – Research and Education Program for Wheelchair Standards
  - RESNA – Balloting and Membership
  - Beneficial Designs

RESNA Draft Standards

- RESNA WC-1: 2009 Wheelchairs – Volume 1: Requirements and Test Methods for Wheelchairs (Including Scooters)
- RESNA WC-2: 2009 Wheelchairs – Volume 2: Additional Requirements for Wheelchairs (Including Scooters) with Electrical Systems

RESNA National Standards

- RESNA WC-1: 2000 Wheelchairs – Volume 1, Section 19: Wheelchairs used as seats in motor vehicles
- RESNA ASE-1: 2007 Adaptive Sports Equipment – Volume 1: Winter Sports Equipment

Universal Design of Fitness Equipment (UDFE) Standards

- Accessible "mainstream" fitness equipment – user friendly
  - Health benefits
  - Social benefits
    - Increase access by persons with impairment
    - Decrease cost of accessible fitness equipment

Example: Chest Press with minimal access

Typically:

- Non-removable seat
- Pin/adjustment locations
- No information
- High start weight

Example: Chest Press with greater acces

Increased Access:

- Wheelchair access
- Reachable pins/ adjustments
- Color contrast
- Low start weight

Americans with Disabilities Act (ADA)

- Title III applies to public accommodations
- People of all abilities:
  Access fitness centers
  Access fitness equipment
  - Including those with disability
    - Physical
    - Sensory
    - Cognitive

Accessible Fitness Equipment Milestones

- Beneficial Designs
  NIH/NICHD SBIR Phase I grant
  - United States Guidelines
  - Universal Design of Fitness Equipment (UDFE) (2006)
- Inclusive Fitness Initiative (IFI)
  - United Kingdom Guidelines
  - IFI Standards Stage Two (2006)

RecTech Mission

Increase fitness and recreation:

- ACCESS
- PARTICIPATION
- ADHERENCE

Promote HEALTH and FUNCTION

RecTech

NIDRR Rehab Engineering Research Center (2007)

Using technology to promote more healthy, active lifestyles for people with disabilities

Development Project to harmonize UK and US Guidelines -

Uniform Standards for Accessible Fitness Equipment Specific Aims

- Evaluate and refine the draft Universal Design of Fitness Equipment (UDFE) Guidelines
- Develop a UDFE Standard by participating in ASTM

Compare the UK and US Guidelines

- IFI (UK)/UDFE (US- Beneficial Designs)
  - General Requirements
  - Strength Equipment
  - Cardiovascular Equipment

UDFE/UK Harmonization Score Developed

- 1= equivalent guidelines
- 2= similar (both objective)
- 3= not equal (objective v subjective)
- x= missing criteria

Example: Treadmill Step-Up Height

- IDEAL – 0 in:
  Belt flush with ground, built-in treadmill
- ADAAG – 7 in:
  Stairs – Max 7 in height
- IFI/UDFE – 2 in to 6.7 in:
  Researching/Negotiating – 5.75 in?
  - Harmonization score = 2 - similar

Progress 2008 – 2009

- Spreadsheet comparison:
  - 27 specifications = 1 (equivalent), **now 239**
  - 144 specifications = 2 (similar), **now 54**
  - 43 specifications = 3 (not equal: objective v subjective), **now 11**
  - 193 specifications = missing, **now 73**

ASTM F08.30 Fitness Products Meetings

- May 2008 Work meetings – Denver
  - Inclusive fitness standards embraced
- Nov 2008 Work meetings – St. Louis
  - Presented uniform set of draft guidelines
  - ASTM WK19803 – New Work Item
- May 2009 Work meetings – Vancouver
  - Title/Scope/Rationale

Unknown Design Variables

- Auditory feedback
- Color contrast
- Static grip handle shape/diameter
- Treadmill step-on height
- International anthropometric data set
- Push/pull/twist specifications
- Wheelchair force tolerance during weight lifting

Auditory Feedback Research

- IFI currently conducting research in the UK
  - Auditory feedback options for people with vision impairment
  - Issues: privacy, non-intrusive to other gym members

Color Contrast Research

- IFI algorithm
  - Complicated to perform in field
- ASTM standard for tile color
  - Spectrophotometric equipment – expensive
- Need easy, low-cost method
  - ADA – 70% color contrast
  - Evaluating feasibility of Spotmeter use

Accessibility of Fitness Equipment for People using Wheelchairs

- Seat support
- Lateral access
- Facing in or out
- Seat removal
- Weight pin – Adjustment forces

Wheelchair Access to Fitness Equipment

- Accommodation of exercise while seated in a wheelchair will provide access to more users

Removablity of the Seating Support

- Fixed Seating
- Removable Seating
- Swing away Seating
- Adjustable height Seating
  - Increments of adjustment
  - Range of adjustment

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- Structure Height: 11.5”

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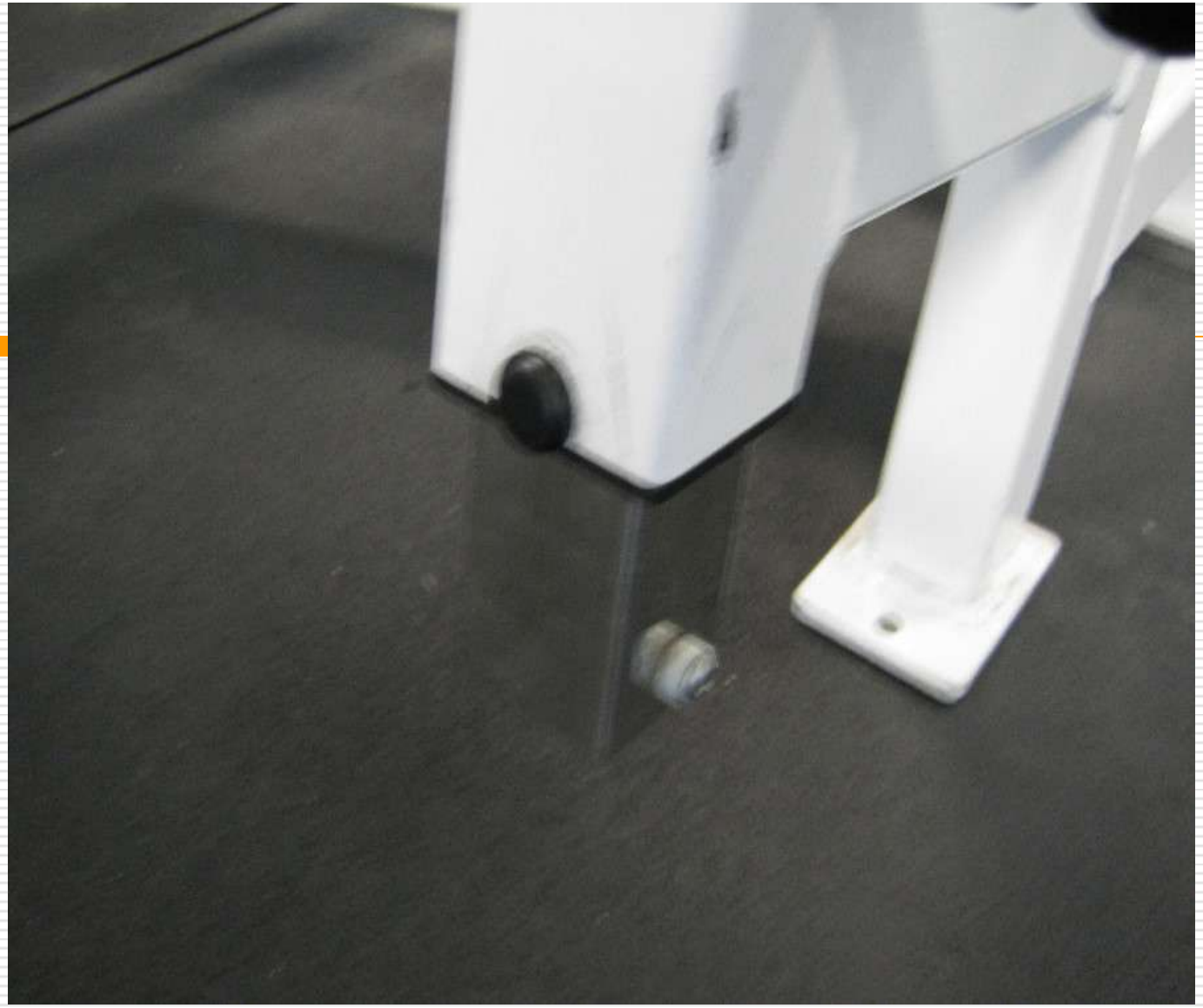

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Front Approach Fitness Equipment

- Transfer often required
- Difficulty getting leg across seat for transfer

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Lateral Rowing Machine

- Removed seat support
- Forward access
- Remaining structure 14.5” high
- Wheelchair cross frame limits access

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BALANCE
BL

Chest Press with a Forward Projecting Back Support Pad

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Fitness Equipment Seating Supports – Data Collection

- Width
- Depth
- Thickness
- Shape
- Angle
- Height
- Lateral clearance for transfer
- Removability and height of remaining structure

Measurements of Fitness Equipment Seating

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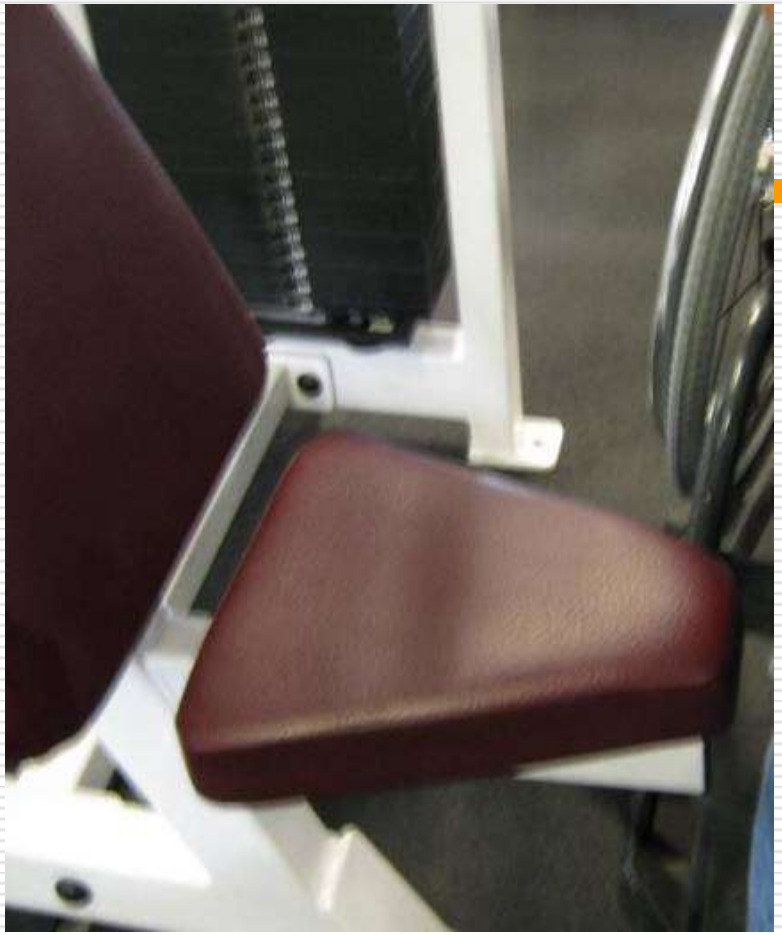
Measurement of Seat Support angle and Clearance

Lateral Access to Fitness Equipment for Transfer

- Wheelchair clear space often does not exist adjacent to equipment
- Provision of solid gripping locations to assist with transfer is beneficial
- Use of exercise actuator grips can be hazardous if they move

Bodymaster Shoulder Press



- Front Width: 4”
- Rear Width: 9.5”
- Depth: 12”
- Fixed Height: 17”
- Seat Angle: 4°
- Seat Thickness: 2.5”

Small seating surface makes leg positioning difficult

Isolateral Shoulder Press with Good Seating

- Front Width: 17”
- Rear Width: 14”
- Depth: 16”
- Infinitely Adjustable Height: 16”-25”
- Seat Angle: 12.8°
- Seat Thickness: 2.5”

Side Approach Clear Space

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Improved Leg support

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Isolateral Shoulder Press with Steep Seat Angle

- Front Width: 17”
- Rear Width: 14”
- Depth: 16”
- Infinitely Adjustable Height: 16”-25”
- Seat Angle: 12.8°
- Seat Thickness: 2.5”

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Effect of Fitness Equipment Design on Strength and Stability of Wheelchairs

- Peter Axelson – Design Engineer
- Seanna Kringen - Standards Writer
- Joey Gmuender – Project Assistant

Stability of Wheelchair Users while using Fitness Equipment

Biomechanics of Exercise Affecting Stability

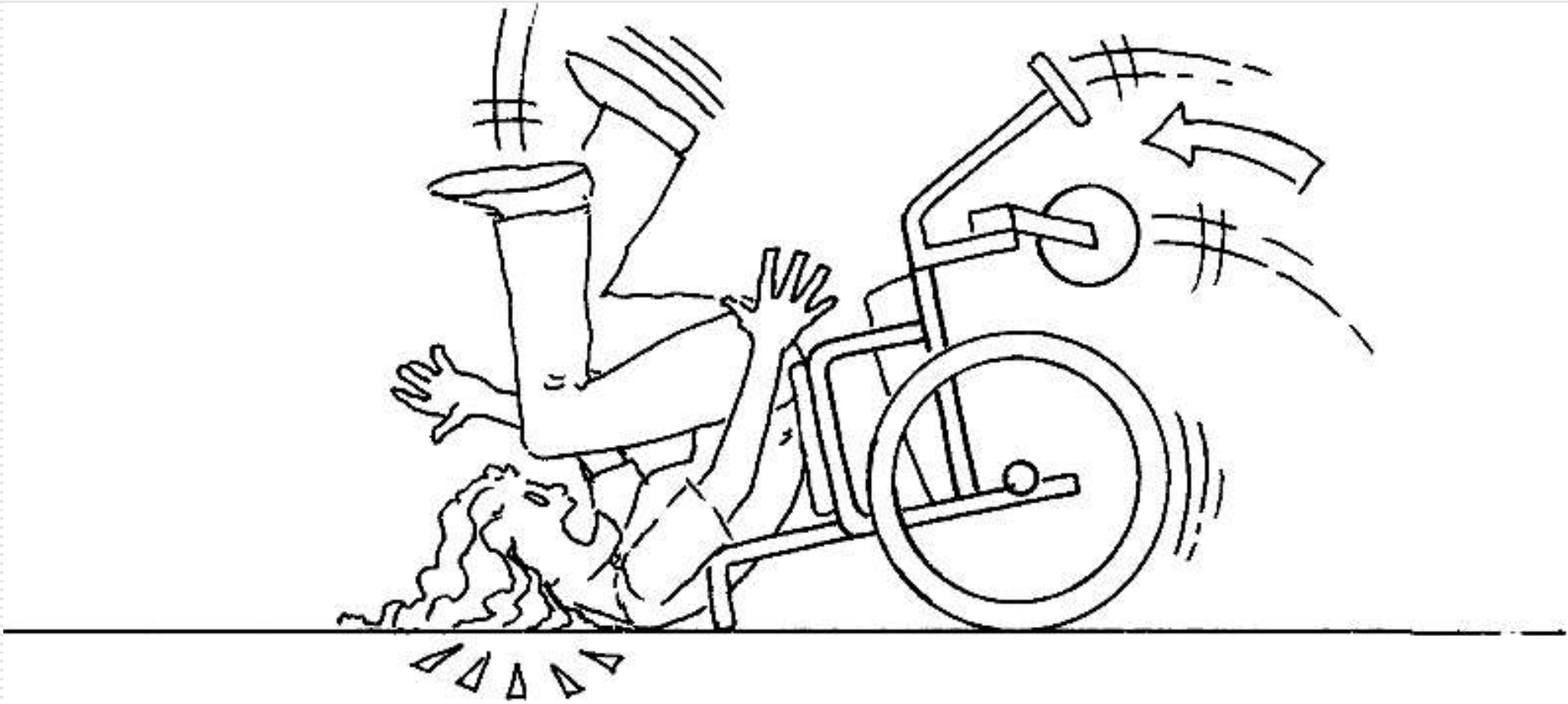
- Amount of force required
- Angle of applied force
- Speed of force application
- User characteristics
- Wheelchair characteristics

User Characteristics Affecting Stability

- Weight
- Height
  - Overall
  - Sitting
  - Shoulder

Rearward Wheelchair Stability

- The forces exerted on a wheelchair when the user is exercising can sometimes cause an instability, causing the user to tip over

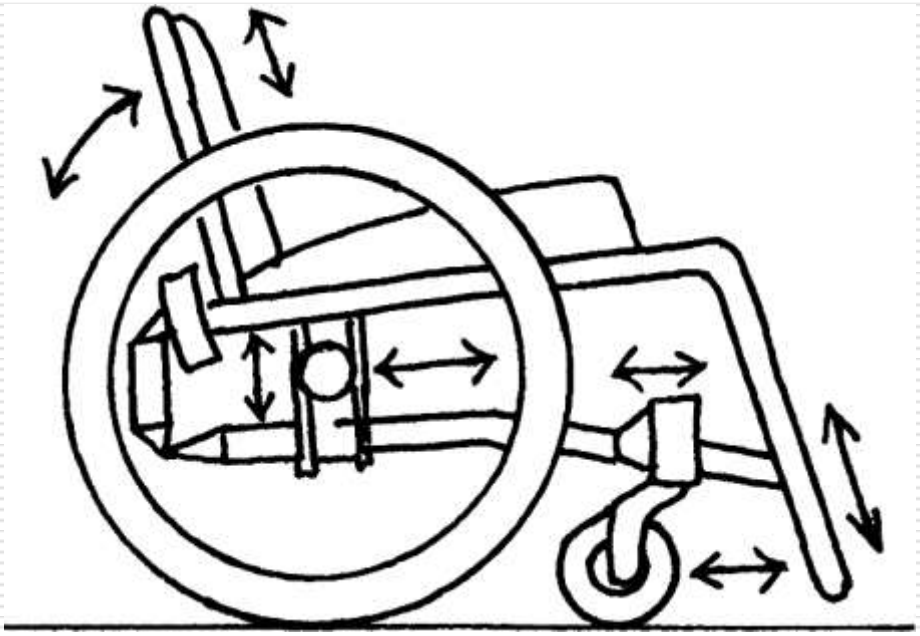


Pushing forward = Rearward force

- On back support of wheelchair
- Support pad provided

Wheelchair Factors Affecting Stability

- Rear axle position
- Seat cushion height
- Seat height
- Angle of back support

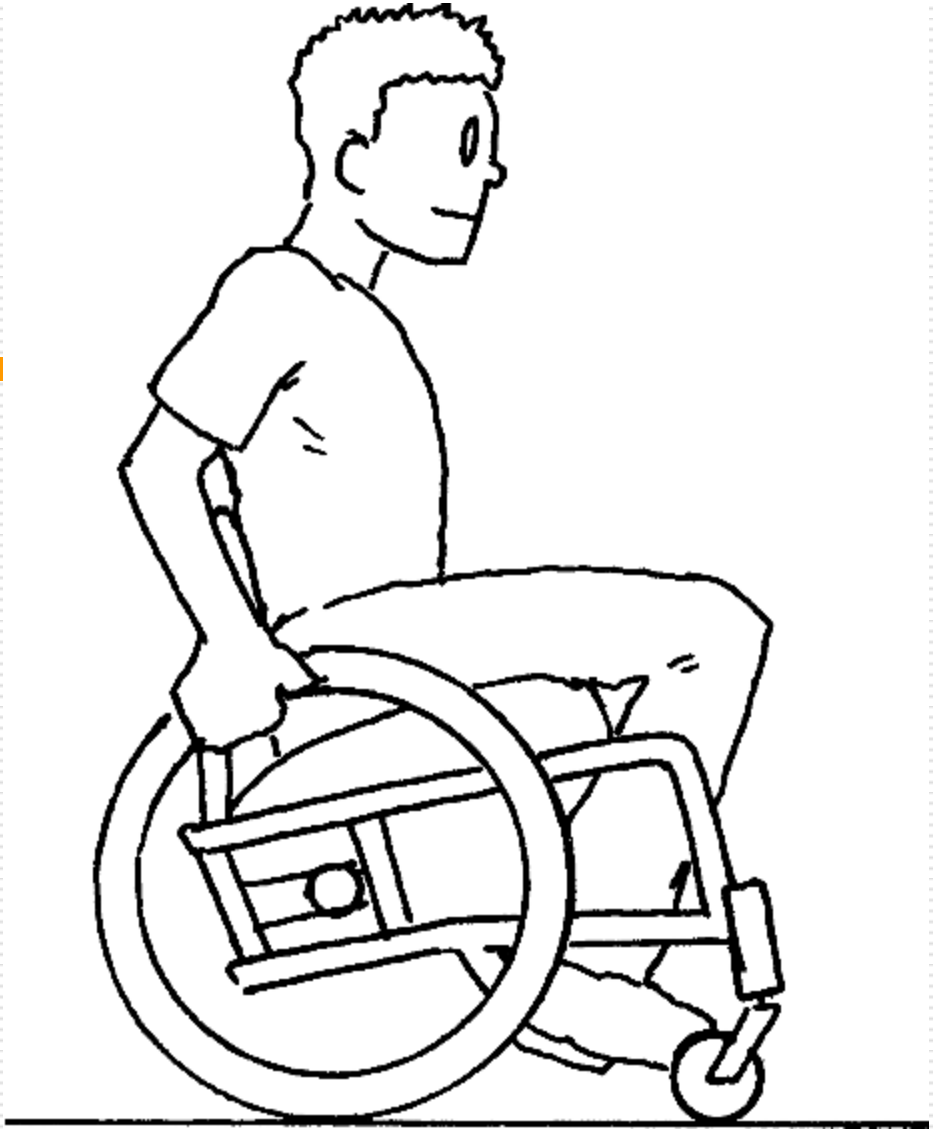


Axle Position Types

- Fixed – Inline with back support
- Adjustable – A set of holes fore and aft for the user to choose
- Infinite – A slot that allows the axle to be positioned anywhere inside of it

Physically Active Users

- Typically have a more forward mounted axle, thus increasing the chance of instability while exercising



Adjustable Position Axle

Investigation of Shoulder Height and Weight on Rearward Stability

Shoulder Height

Shoulder Height	5th Percentile Female	50th Percentile Female	50th Percentile Male	95th Percentile Male
From seating surface for each percentile (cm)	48	53	63	66

Weight

Weight	5th Percentile Female	50th Percentile Female	50th Percentile Male	95th Percentile Male
For each percentile (kg)	51	67	81	108

Overall Height

Overall Height	5th Percentile Female	50th Percentile Female	50th Percentile Male	95th Percentile Male
For each percentile (cm)	154	164	180	191

Test Setup for Measuring Force to Tip

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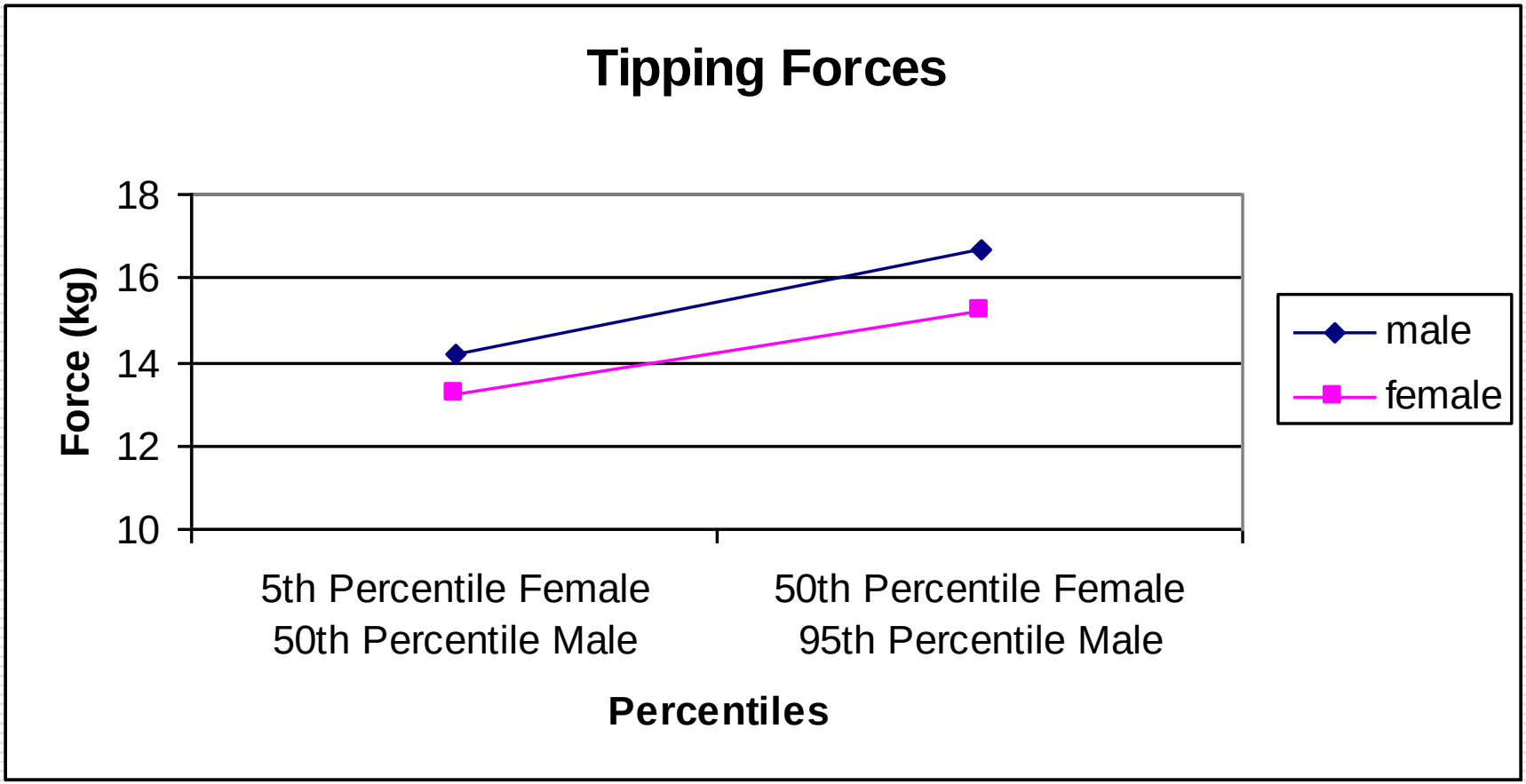
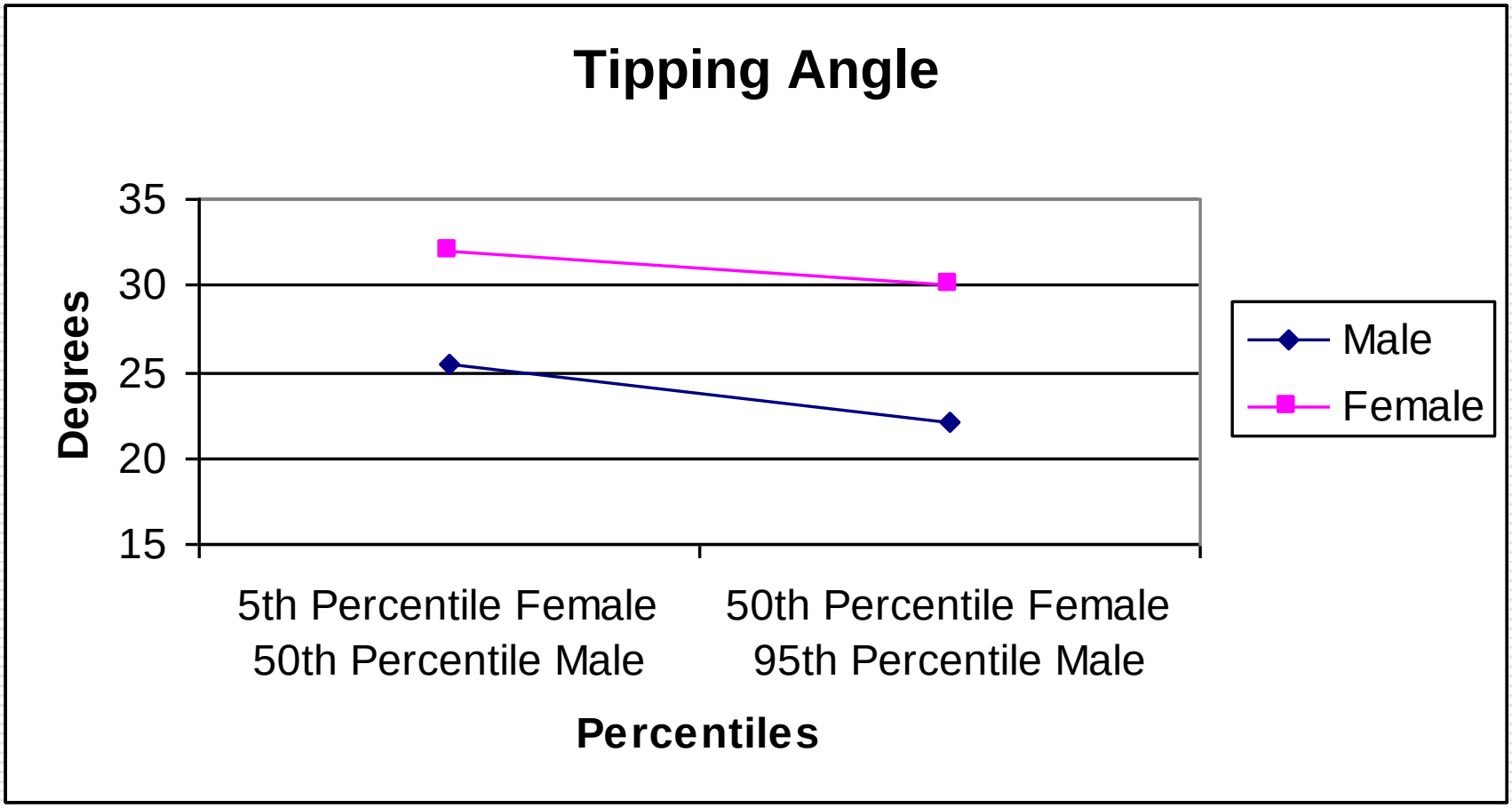
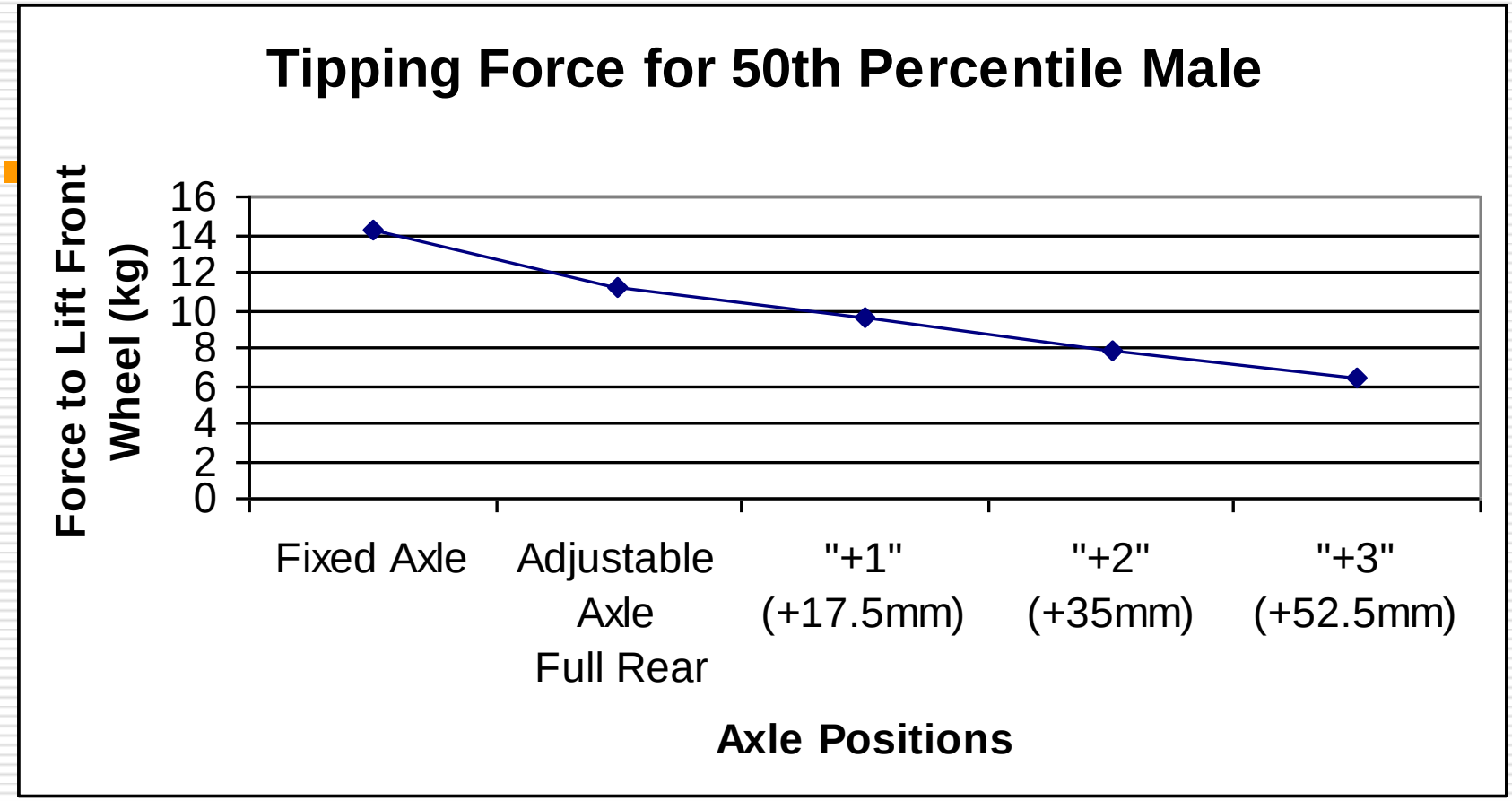
Forces to Tip are Low



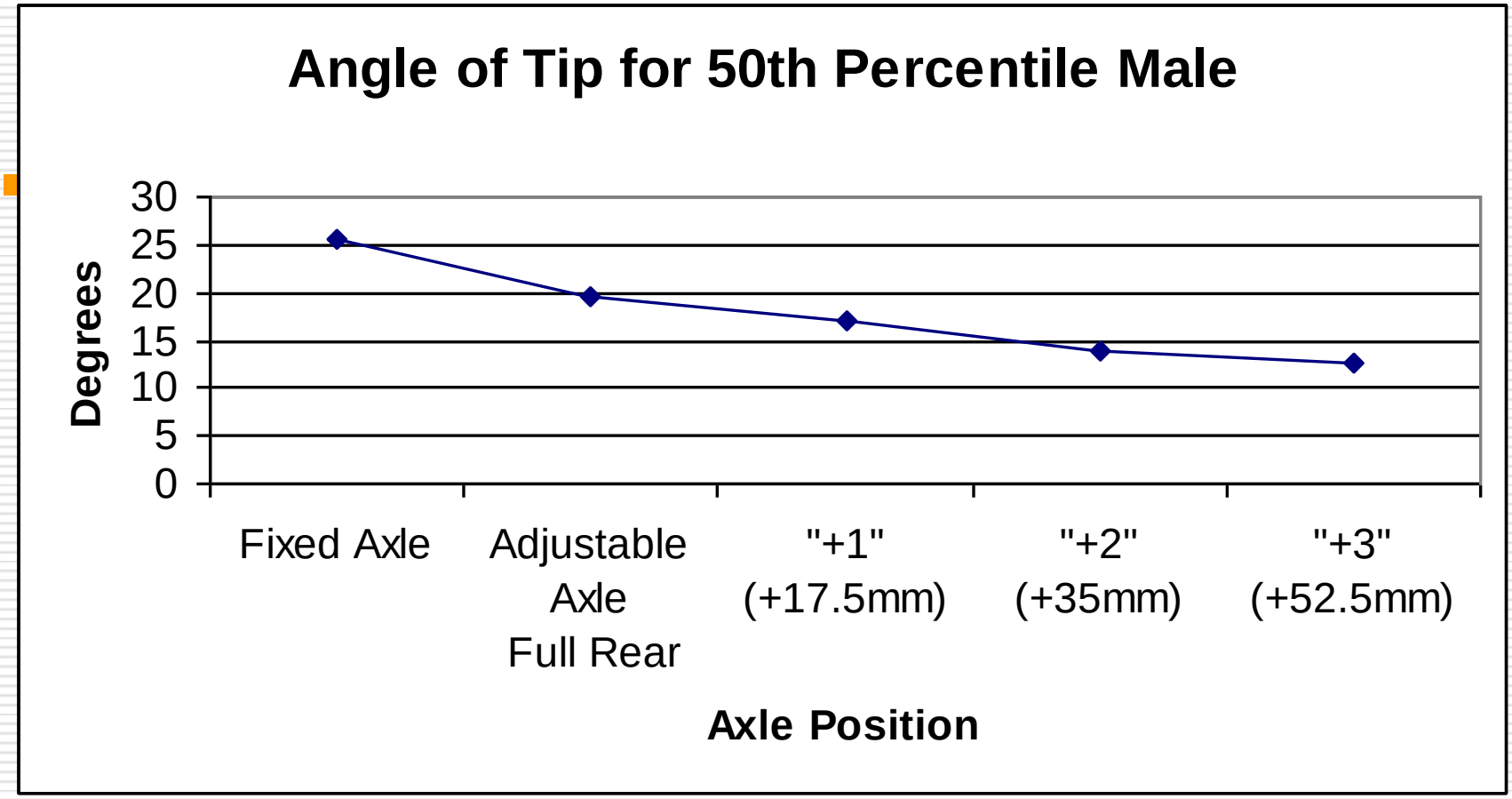
Tip Angles are Noticable



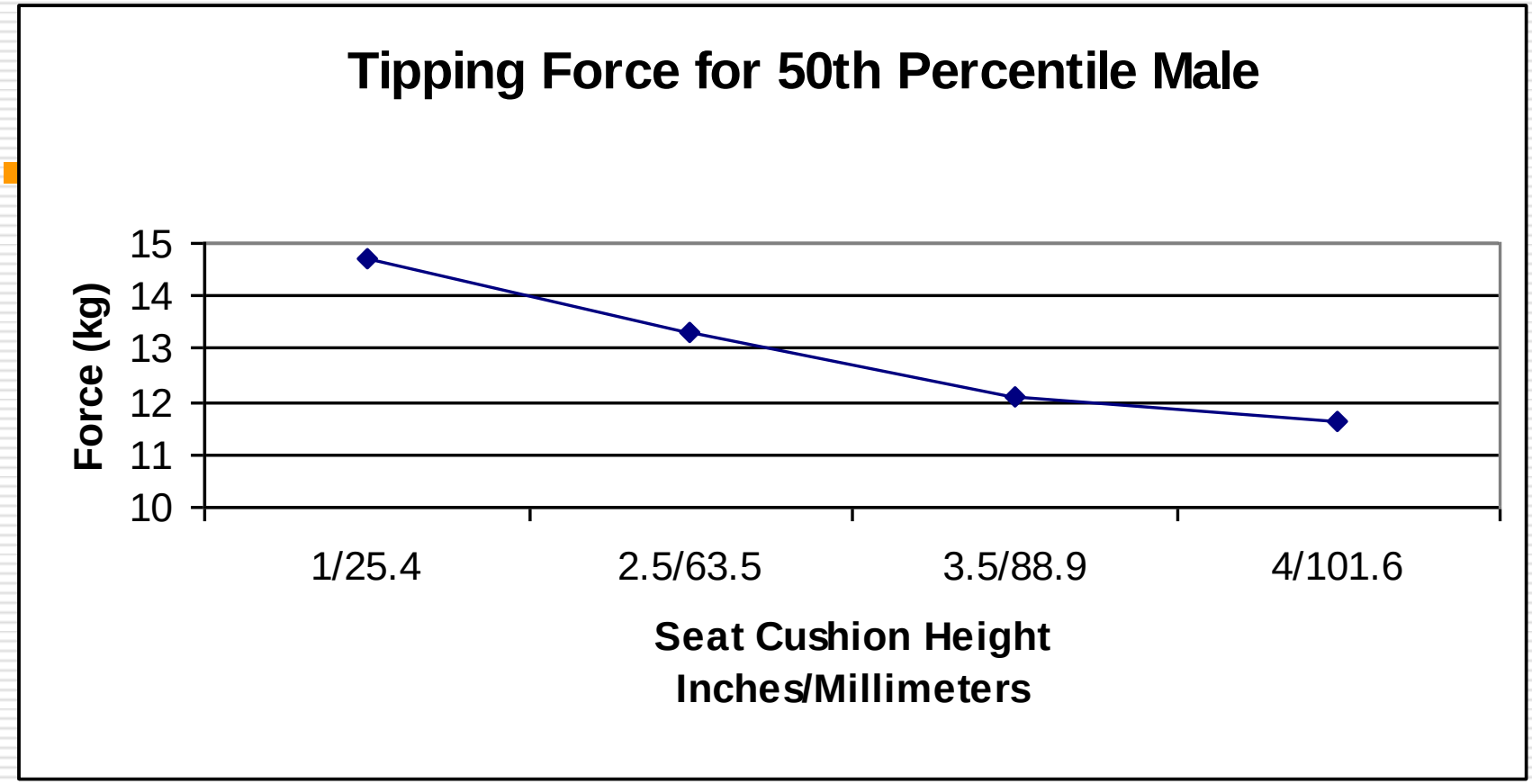
Axle Position Affects Force to Tip



Axle Position Affects Angle of Tip



Seat Cushion Height Affects Force to Tip



Stability of Wheelchair Users using Fitness Equipment

- Factors:
  - User weight
  - User sitting height
  - Fore-aft wheelchair axle position

Shoulder Height

- The taller the shoulder height of the user, the easier it is to tip over backwards

Fore-aft Wheelchair Axle Position

- The further forward the axle position, the easier the wheelchair can tip to the rear
- The further rearward the axle position, the more stable the wheelchair will be to the rear

Investigation – Wheelchair Loading Capacity

Integrity of a Typical Wheelchair when Using Vertical Lift Exercise Equipment

Question/Concern Raised

- What would happen to a wheelchair if it was loaded during exercise with weight beyond its maximum rating of 250 lbs?

Common Wheelchair Warning

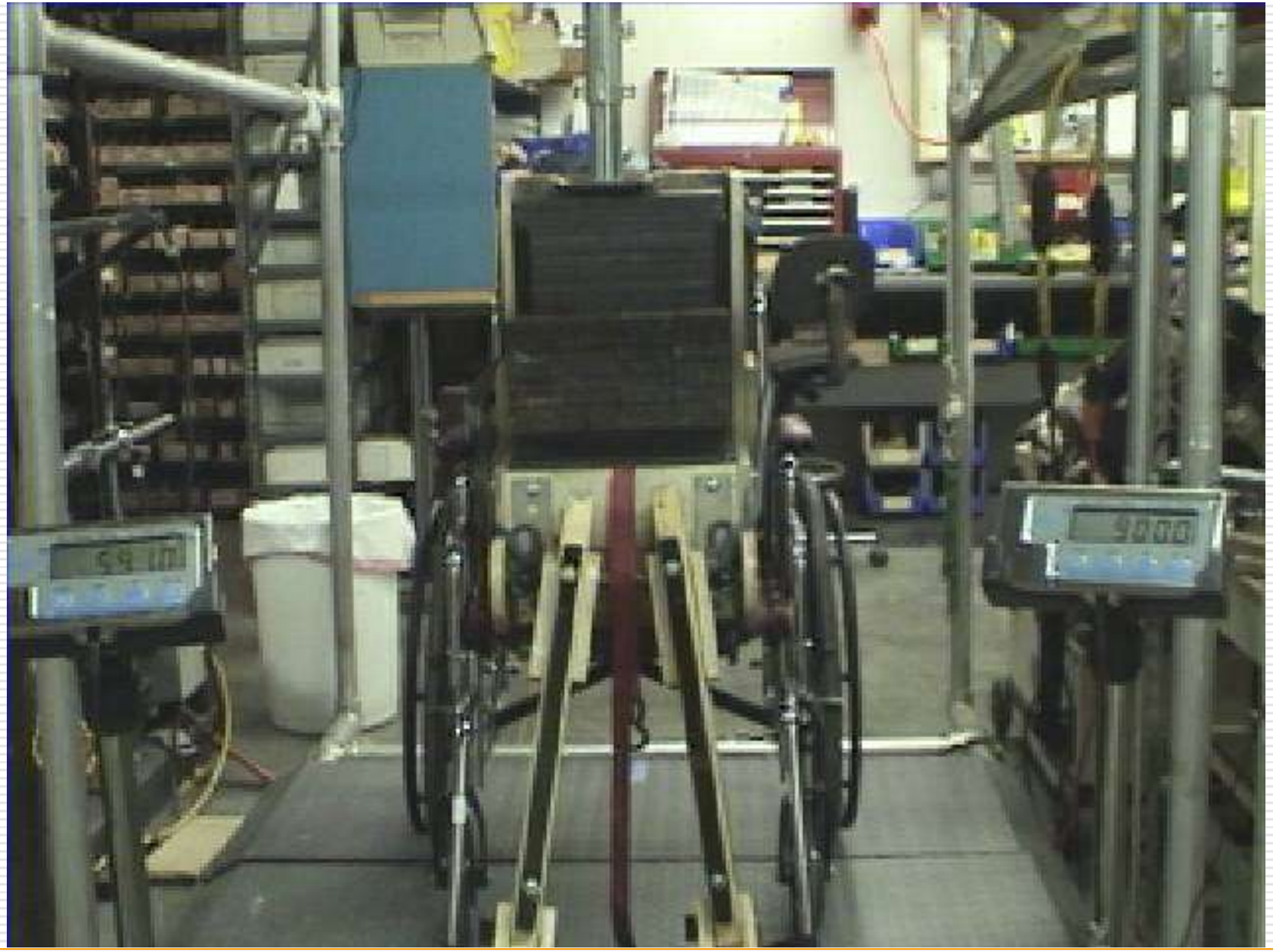
Weight Training
<<Manufacturer>> does not recommend the use of its wheelchairs as a weight training apparatus. <<Manufacturer>> wheelchairs have not been designed or tested as a seat for any kind of weight training. If occupant uses said wheelchair as a weight training apparatus, <<Manufacturer>> shall not be liable for bodily injury or damage to the wheelchair and the warranty is void.

Test Protocol

- A test dummy was setup in a wheelchair and loaded with steel plates
- A fairly generic steel frame, folding wheelchair commonly used in hospitals and airports was used

Test Dummy Load

- Test dummy fully loaded
  - Weight: rear 342.5 lb, front 474.5 lb
  - Total weight: 817.0 lb
- Ram used to further load test dummy
  - Weight: rear 591.0 lb, front 900.0 lb
  - Total weight: 1491 lb



Results – Overall Integrity of the Wheelchair Intact

- Welds and structural joints unchanged
- Front caster angle changed
  - from 21° to 24°
- Seat material stretched

Conclusion

- Loading this particular wheelchair beyond its specified maximum payload as may be experienced during weight lifting was found to not catastrophically effect the wheelchair

Current Safety Methods

- Usually the best way for a person using a wheelchair to access this type of equipment is through the use of a guide or spotter

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Safety Methods

- Weighing down the front of the wheelchair
- Locking down the front of the wheelchair with a strap or hook
- A back support device or pad
- Personal assistance from a trainer

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Next Steps for UDFE Standards

- Research unknown variables
- Develop other sections
  - Elliptical
  - Rowing machine
  - Ergometer
- Promote the ASTM process

Future Goals

- Disability training for fitness staff
- Inclusive fitness programs
- Accessible gym layout
- User friendly labeling

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- Beneficial Designs – Peter Axelson, with the assistance of his staff, is supported to travel and participate in RESNA - national and ISO – International Standards Organization wheelchair standards meetings to develop, write and update wheelchair standard test procedures for manual and powered wheelchairs.

Beneficial Designs, Inc.

- Research/Design/Education
- Improving access for people of all abilities

peter@beneficialdesigns.com
seanna@beneficialdesigns.com

Minden, Nevada

www.beneficialdesigns.com
standards@beneficialdesigns.com
775.783.8822 voice
775.783.8823 fax

Working toward universal access through research, design & education

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