CARDIOPULMONARY FUNCTION AND WHEELCHAIR SEATING AND MOBILITY

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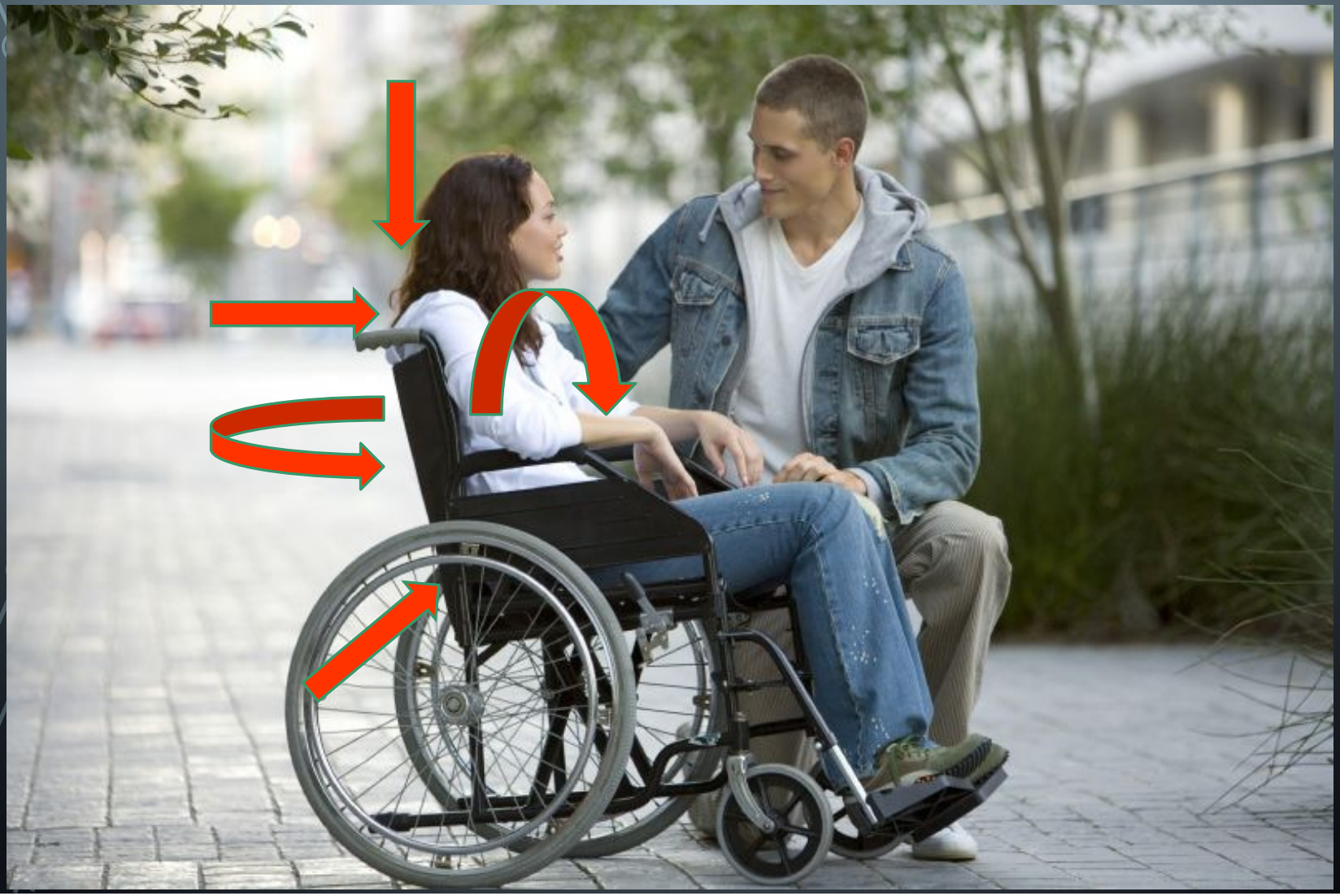
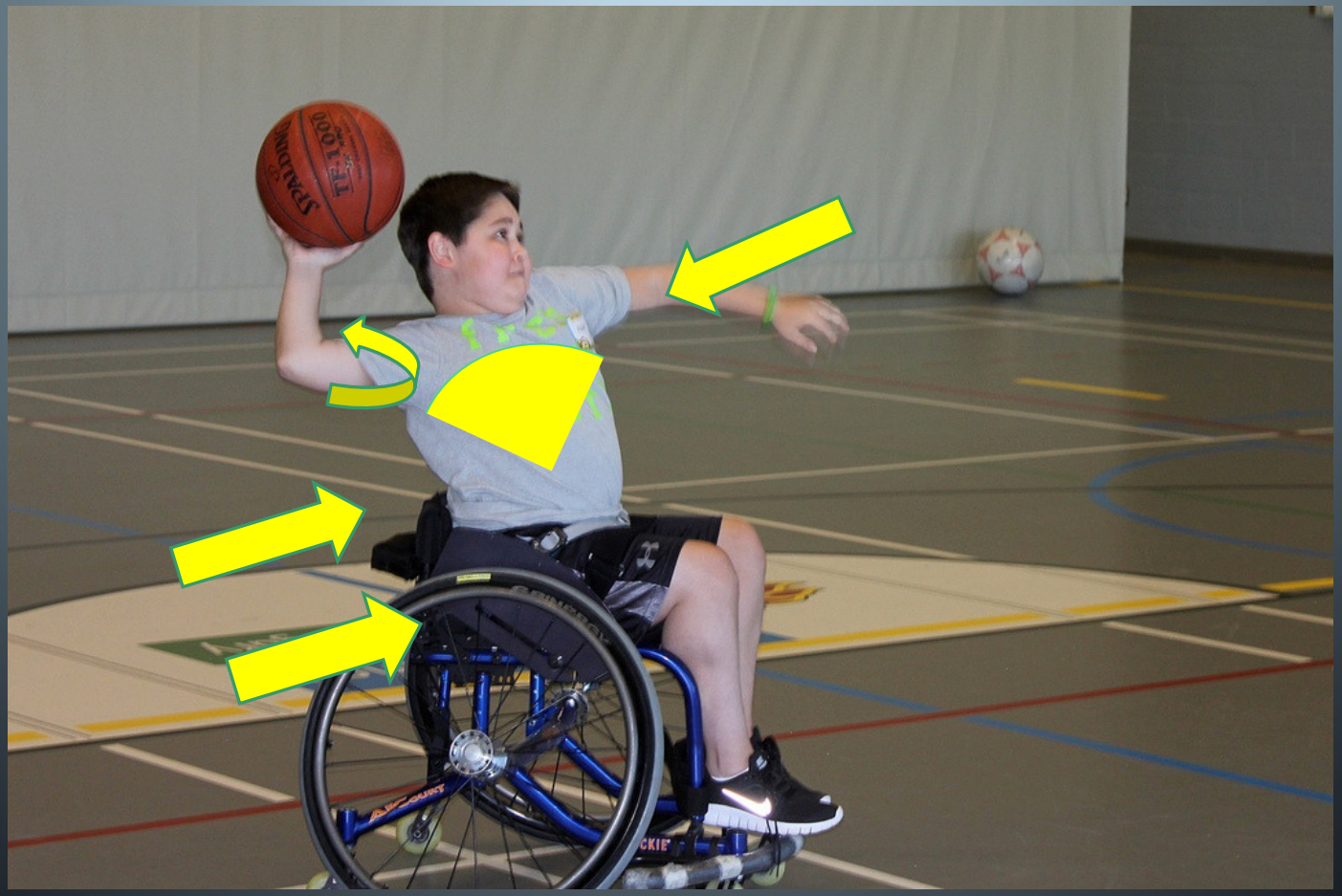
DISCLOSURES

- No disclosures
- Do not intend to promote commercial products or services and I have no financial ties, but for the purpose of providing example, some products will be mentioned.
- Received funding through the Spina Bifida Young Investigators Award from the Spina Bifida Association/Ashley Rose Foundation to complete a study on pulmonary function of people with spina bifida

WHAT'S WRONG WITH THIS PICTURE?



WHAT'S RIGHT WITH THIS PICTURE?



TAKE A DEEP BREATH

BREATHING IS 3-D!

Chest Wall Expansion

- Anterior/Posterior
- Superior/Inferior
- Lateral

Gravity either assists, resists or has no effect on chest wall expansion

WHAT ABOUT CHEST EXPANSION SITTING IN A WHEELCHAIR?

- **Sitting**
  - Anterior Expansion
    - Gravity eliminated
  - Posterior Expansion
    - Inhibited by postural support surface
  - Lateral Expansion
    - Gravity eliminated
  - Superior/Inferior Expansion
    - Against gravity

HOW TO ASSESS CHEST EXPANSION?

BY OBSERVATION, PALPATION, MEASUREMENT

OBJECTIVE 1

Discuss three impairments associated with people who have neurological conditions and potential secondary conditions that can impact morbidity and mortality

- Pulmonary restriction
- Pneumonia
- Atelectasis

ABNORMAL PHYSIOLOGY

Health Condition

Respiratory muscle weakness or paralysis, or abnormal tone with neurological condition

Body Function

- Restricts chest expansion, ventilation, cough force (need those abs!)

Body Structures

- Retained secretions & atelectasis

Consolidation may also occur from aspiration, pneumonia, pulmonary edema, hemorrhage

ANATOMY

Every muscle originating or inserting on the trunk is a respiratory AND

a postural muscle

Breathing always wins in the competition between maintaining postural control and taking breaths

(Mary Massery, 2003)

SPINA BIFIDA - BACKGROUND

Myelomeningocele, most severe and prevalent form (75%, n= 7,924) leading to lifelong disability

Denervation of sensory and motor nerves at/below spinal lesion

Use of wheelchairs, braces, or crutches for mobility.

Requires multidisciplinary care due to multi-system involvement

(Dicianno et al 2008, Allam and Schwabe 2013)

Increased risk of obesity, hypertension, cardiovascular disease, metabolic syndrome, pulmonary complications, sleep disordered breathing, lymphedema, physical inactivity

(Dosa 2009, Stepanczuk 2013, Buffart 2008, Nelson 2007, Sherman 1997, Waters 1998, Garcia)

SPINA BIFIDA - BACKGROUND

Pulmonary dysfunction is common source of morbidity and mortality

Restrictive lung disease is a predisposing factor for pneumonia, impaired exercise tolerance and QOL (Chang et all 1999, O'Donnell 2000, Sherman 1997)

Pneumonia and **respiratory failure** were 2nd and 3rd leading **causes of mortality** (Dicianno & Wilson 2010)

SPINA BIFIDA

Possible contributors to pulmonary dysfunction:

- **Scoliosis**
  - Prevalence: 52% > 10 years old (Allam, 2013)
  - Non-ambulators more likely to develop scoliosis (Vialle 2013)
- **Obesity**
  - Prevalence: 35% of adults (Dosa, 2009)
  - Reduces chest wall compliance/diaphragmatic excursion
- **Denervation of muscles of respiration**
  - (Schilero 2009, Seddon 2003, Galeiras 2013)

IMPACT OF NEUROLOGICAL LEVEL AND SPINAL CURVATURE ON PULMONARY FUNCTION IN SPINA BIFIDA

THERESA M. CRYTZER, PT, DPT, ATP; YU-TING CHENG, MS; MARY JO BRYNER, BS, RRT, RPFT; ROBERT WILSON III, MS, CPFT; FRANK C. SCIURBA, MD; BRAD E. DICIANNO, MD, MS

AIMS

1. Describe the pulmonary function of adolescents and adults with SB

2. Determine impact of neurological level of spinal lesion, scoliosis and obesity on pulmonary function

METHODS
PARTICIPANTS

Inclusion criteria:

- Age 13 – 80
- Spina bifida
- Scoliosis
- Unable to pedal 2-wheel bicycle

METHODS
OUTCOME MEASURES

Sociodemographic

Body composition (arm span)

Neurological level (AIS)

Functional mobility (10MWT)

Pulmonary Function Tests

Arm Ergometry Exercise Stress Test

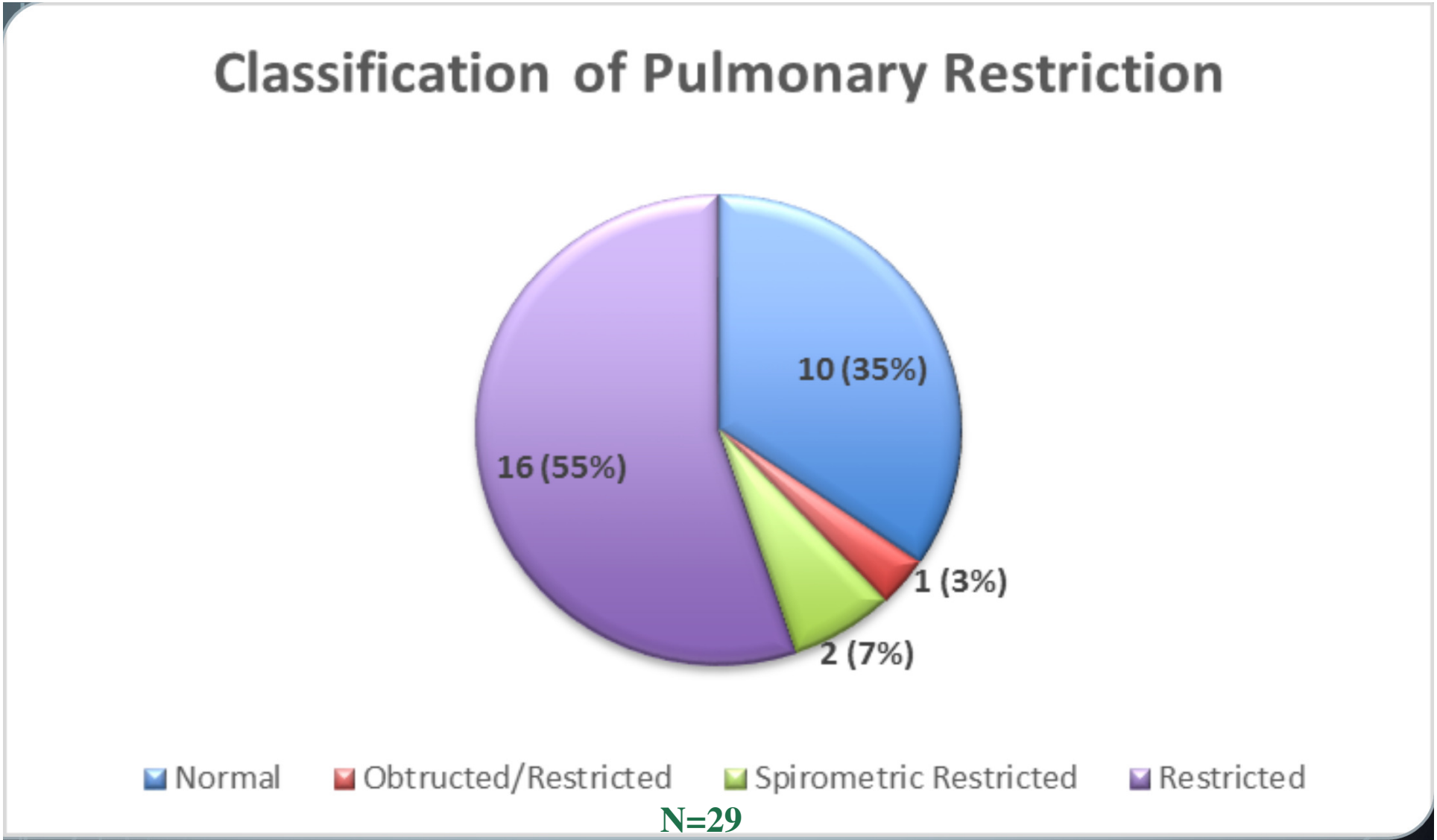

Classification of Pulmonary Restriction
10 (35%)
1 (3%)
2 (7%)
16 (55%)
Normal
Obtructed/Restricted
Spirometric Restricted
Restricted
N=29

FIGURE 1

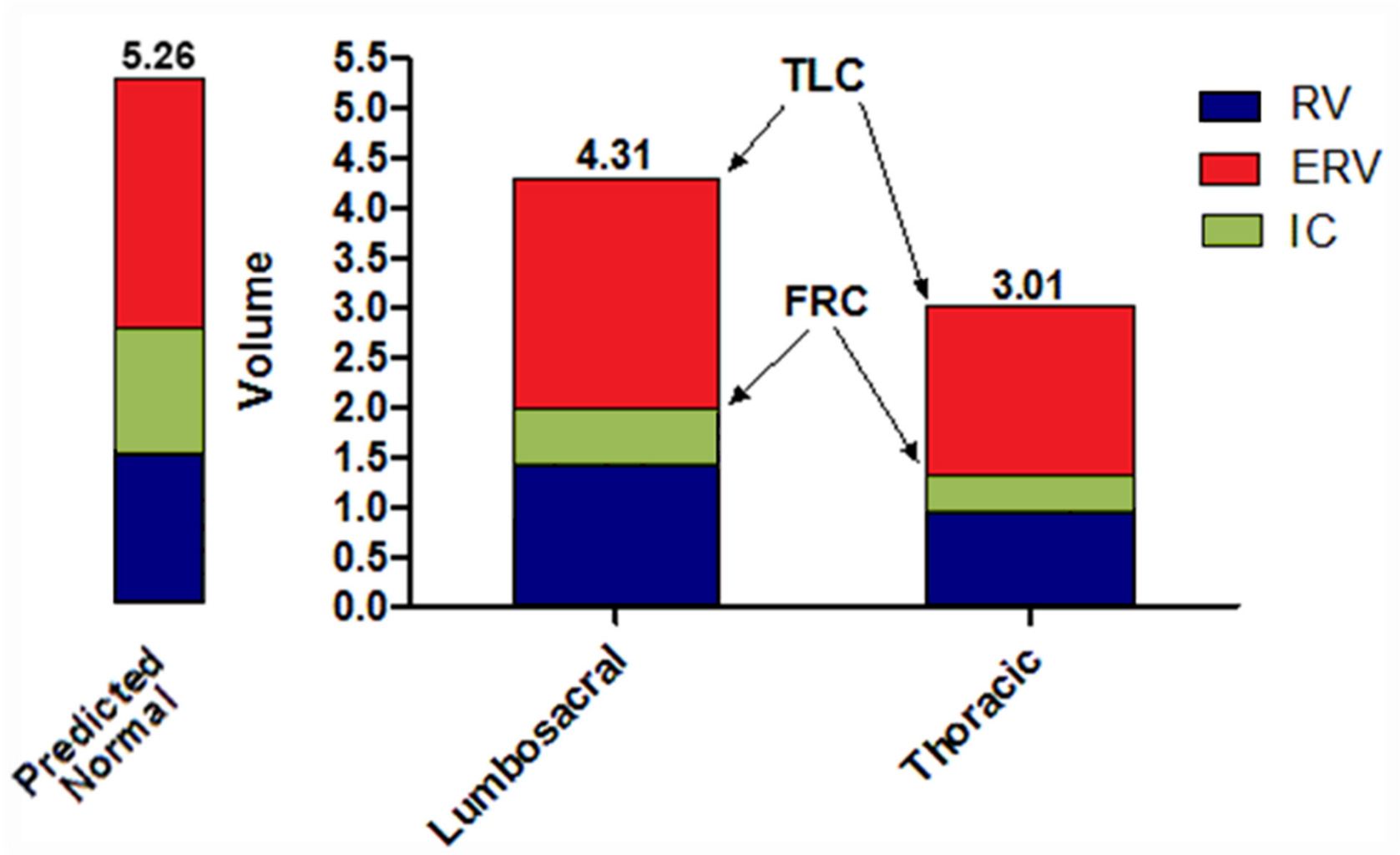

5.26
Volume
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
TLC
FRC
4.31
3.01
RV
ERV
IC
Predicted Normal
Lumbosacral
Thoracic

Figure 2

RESULTS

High prevalence of pulmonary restriction

Restrictive pulmonary function in 9/10 (90%) of those with thoracic motor level

More rostral motor level & greater degree of scoliosis associated with higher degree of pulmonary function impairment

SPINAL CORD INJURY

SPINAL CORD INJURY- PREVALENCE OF RESPIRATORY COMPLICATIONS

- Most vulnerable to respiratory illness in year 1 after SCI
- Continue to face respiratory complications through life
- Leading causes of death in SCI (pneumonia, pulmonary embolism, sepsis, coronary artery disease)

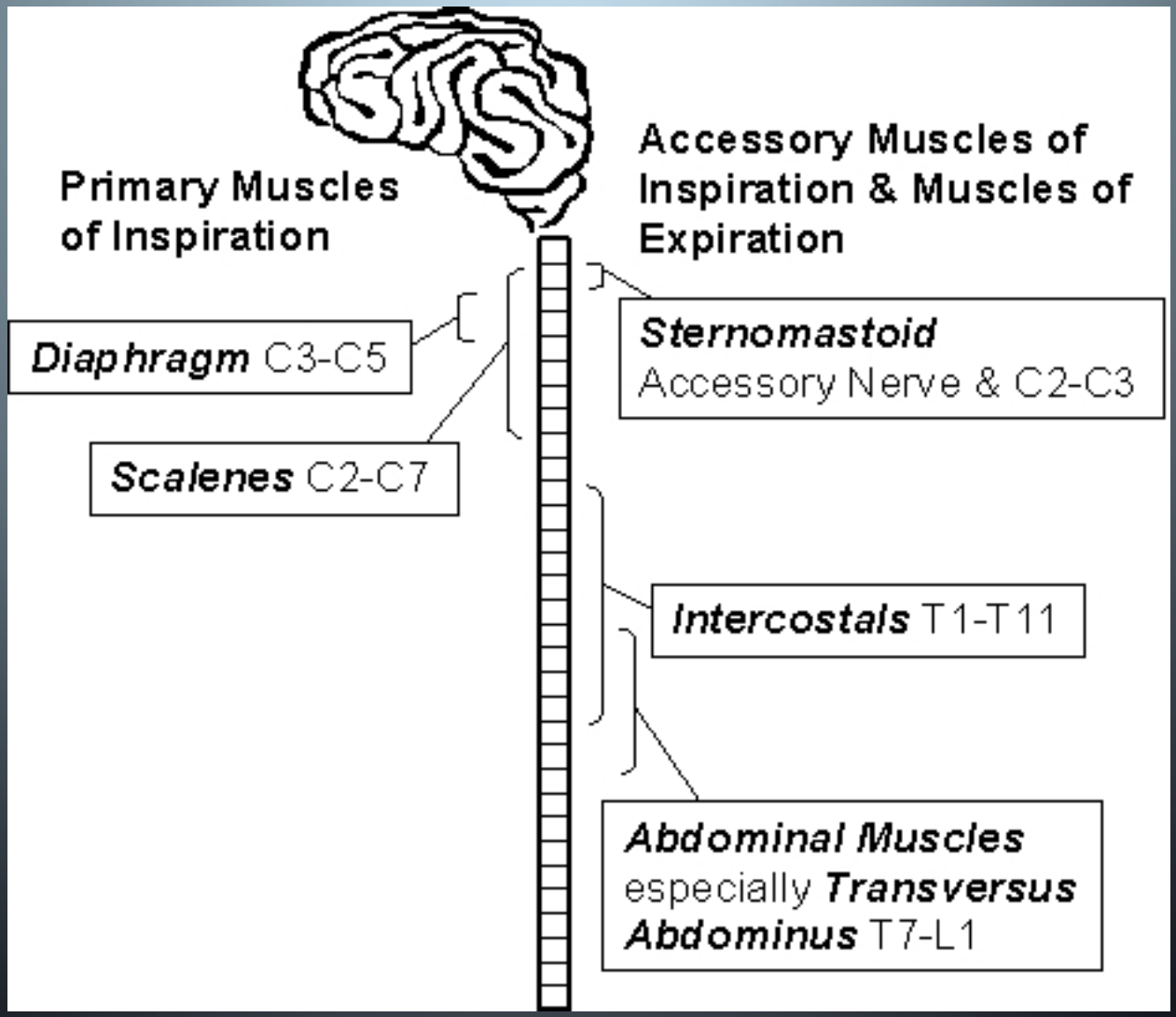
-Berlowitz, et al (2016) Respiratory problems and management in people with spinal cord injury. *Breathe* 2016; 12: 328–340.
-Linn WS; Adkins RH; Gong H Jr; Waters RL (2000) Pulmonary function in chronic spinal cord injury: a cross-sectional survey of 222 southern California adult outpatients. Arch Phys Med Rehabil Jun;81(6):757-63.

NEUROLOGICAL LEVEL AND RESPIRATORY IMPAIRMENT/ SUPPORT

- **C1–C3** - Likely full-time ventilator need due to diaphragm paralysis. May come off vent briefly
- C3–C4 - Diaphragm impaired, tidal vol. and vital capacity reduced. Periods of ventilator-free time likely. May be adequately supported with nocturnal ventilation alone. At home non-invasive vent support may be used if lung volumes high enough during day while seated
- C5 - Independent respiration possible in long term although initial ventilatory support common Diaphragm function intact but intercostal and abdominal muscle paralysis results in decreased lung volumes, and cough strength/effectiveness
- **C6–8** - Typically can augment inspiration and cough with accessory muscles (pec major/minor)
- **T1–T4** - Inspiratory capacity and forced expiration supported by intercostal activity; but weak cough due to abdominal (expiratory) weakness
- T5–T12 - Progressive relative improvement in muscle strength at descending lesion levels Minimal disruption to autonomic dysfunction affecting the cardiovascular system below T6
- T12 - Respiratory function essentially comparable to that of an able-bodied person

Berlowitz et al, (2016) https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5335574/pdf/EDU-0126-2016.pdf

RESPIRATORY MUSCLE INNERVATION



AUTONOMIC DYSREFLEXIA IN SCI

↑ BP when noxious visceral or cutaneous stimuli are sensed below level of the lesion

Signs & Symptoms

Headache

Nasal stuffiness

Sweating above injury level

Goosebumps below injury

Increased spasticity

Blotching of the skin

Slow pulse (< 60 bpm)

TREAT AS MEDICAL EMERGENCY

RESPONSE TO AUTONOMIC DYSREFLEXIA

- Sit up or raise head to 90 degrees + lower legs
- Loosen/remove constricting clothing.
- Check Blood Pressure x 5 minutes.
- Complete catheterization/bowel program
- Continue to look for stimulus and remove:
  - kink in urinary catheter or bowel impaction
  - wounds, skin tears, ingrown toenail, braces, sunburn

https://www.christopherreeve.org/living-with-paralysis/health/secondary-conditions/autonomic-dysreflexia

ORTHOSTATIC HYPOTENSION

- Common in early acute phase after SCI
- Decrease in systolic BP of 20mmHg or > OR reduction in diastolic blood pressure of 10mmHg or > upon changing body position from supine to upright, regardless of the presence of symptoms
- Symptoms – watch for dizziness, lightheaded, feeling of passing out
- Provide additional time to sit up and transfer
- Stay close

POSITIONING CONSIDERATIONS- PREVENTION OF PNEUMONIA

- **Power chair users**
  - Frequent changes of position using seat function to move air
  - Lumbar/thoracic support for spinal extension
  - External rotation shoulder
  - Monitor O2 sats, HR, RR, BP, observe facial expression
- **Manual chair users**
  - Least back support needed that promotes spinal extension and chest wall expansion
  - Foster trunk rotation
  - Foster unimpeded shoulder/scapular range of motion

PROVIDING DIAPHRAGMATIC SUPPORT

- Abdominal Binder

- Provides flexible support to diaphragm
- Reduces orthostatic hypotension
- Improved pulm function

- TLSO with lateral and abdominal cutouts

http://surestep.net/products/tlso/

CEREBROVASCULAR ACCIDENT (STROKE)

STROKE

Weakness or spasticity may involve respiratory musculature (diaphragm and intercostals)

Paralysis of hemi diaphragm affects balance and posture, impacting normal respiration

Pulmonary function testing reveals decreased volumes and flows to 60-70% of normal

Lack of clinical symptoms may be due to low levels of exertion

PULMONARY COMPLICATIONS OF STROKE

- **Pneumonia**
  - ~5% of patients
  - More common with acute ischemic stroke and with nasogastric tube feeding
  - Risk factors:
    - mechanical ventilation
    - infarcts in multiple locations
    - dysphagia
- **Aspiration** causes 60% of post-stroke pneumonia

ASPIRATION PNEUMONIA

- Pulmonary consequence of abnormal entry of fluid or particulates into the lower airways due to:
  - **Dysphagia** or decreased level of consciousness
  - Compromised cough reflex or glottic

ATELECTASIS

- Prevalent in stroke and other neuromuscular conditions (SB, SCI, MD, ALS)
- Mobility and positioning are important in prevention

SIMPLE LOW-COST CARDIOPULMONARY OUTCOME MEASURES

- Review 5 outcomes for use in support of clinical decision-making in wheelchair prescription

10 METER WHEEL TEST (10 MWT)

- Before 10MWT: Measure SAO2, RR and WHEEL Scale RPE

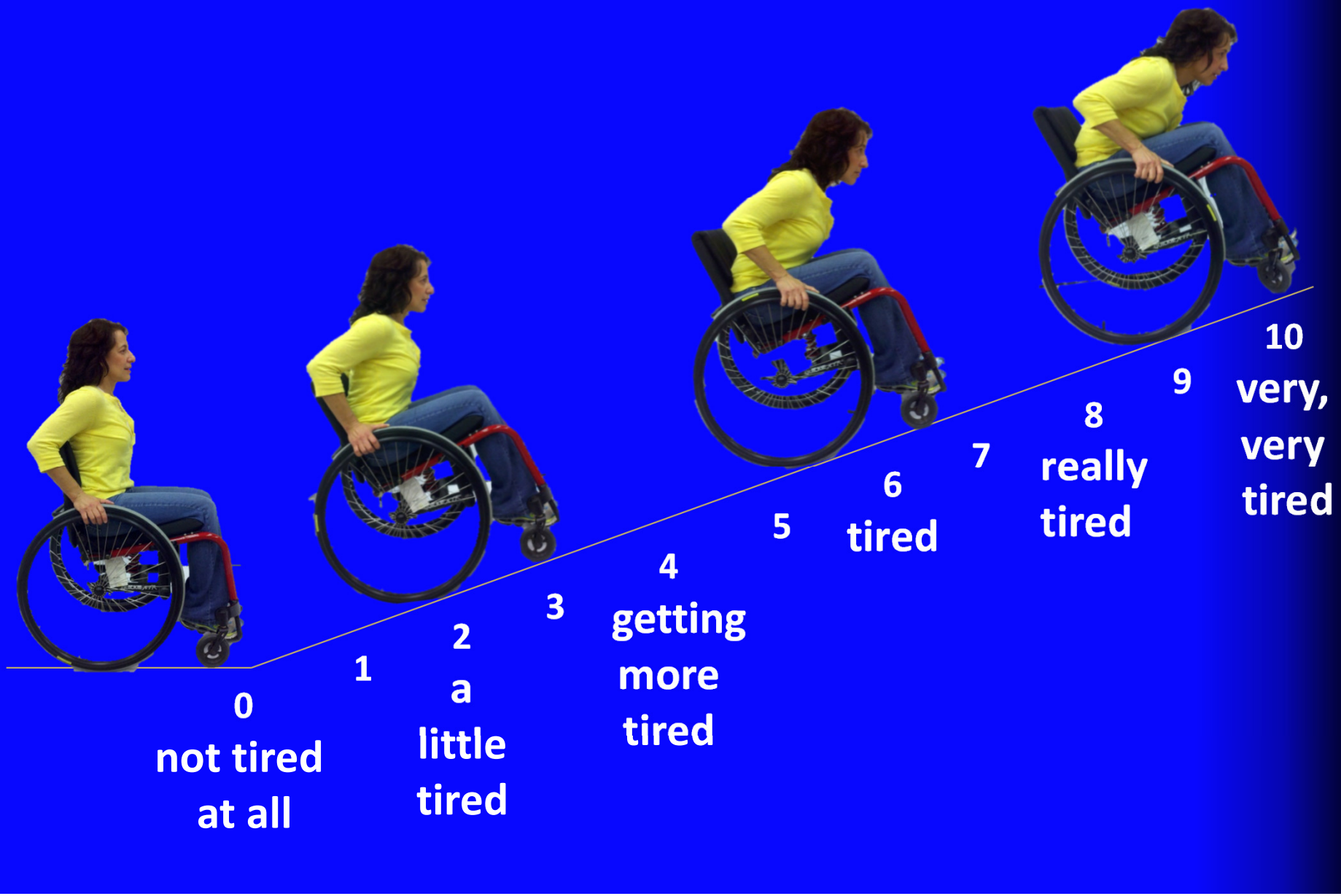
  "*Propel 30 feet at your normal every-day pace*" Start timer as soon as start propulsion.

- After 10MWT: Measure SAO2, RR, and WHEEL Scale RPE

Sussan Askari, Kirby L, Parker K, Thompson K, O'Neill J. (2013)

WHEEL RPE

Crytzer, T. M., Dicianno, B. E., Robertson, R. J., & Cheng, Y.T. (2015).



Borg Rating of Perceived Exertion Scale

6

7 Very, very light

8

9 Very light

10

11 Fairly light

12

13 Somewhat hard

14

15 Hard

16

17 Very hard

18

19 Very, very hard

20

Borg GA. Psychophysical bases of perceived exertion. *Med Sci Sports Exerc.* 1982;14(5):377-381.

TIMED UP AND GO

- **<u>Before TUG</u>: SAO2, RR, HR, Borg RPE**
- Verbal: “Stand up, walk 10 feet, turn around, walk back, sit down”
- Start your stopwatch as soon rear leaves chair
- **<u>After TUG</u>: SAO2, RR, HR, Borg RPE**
- Reference

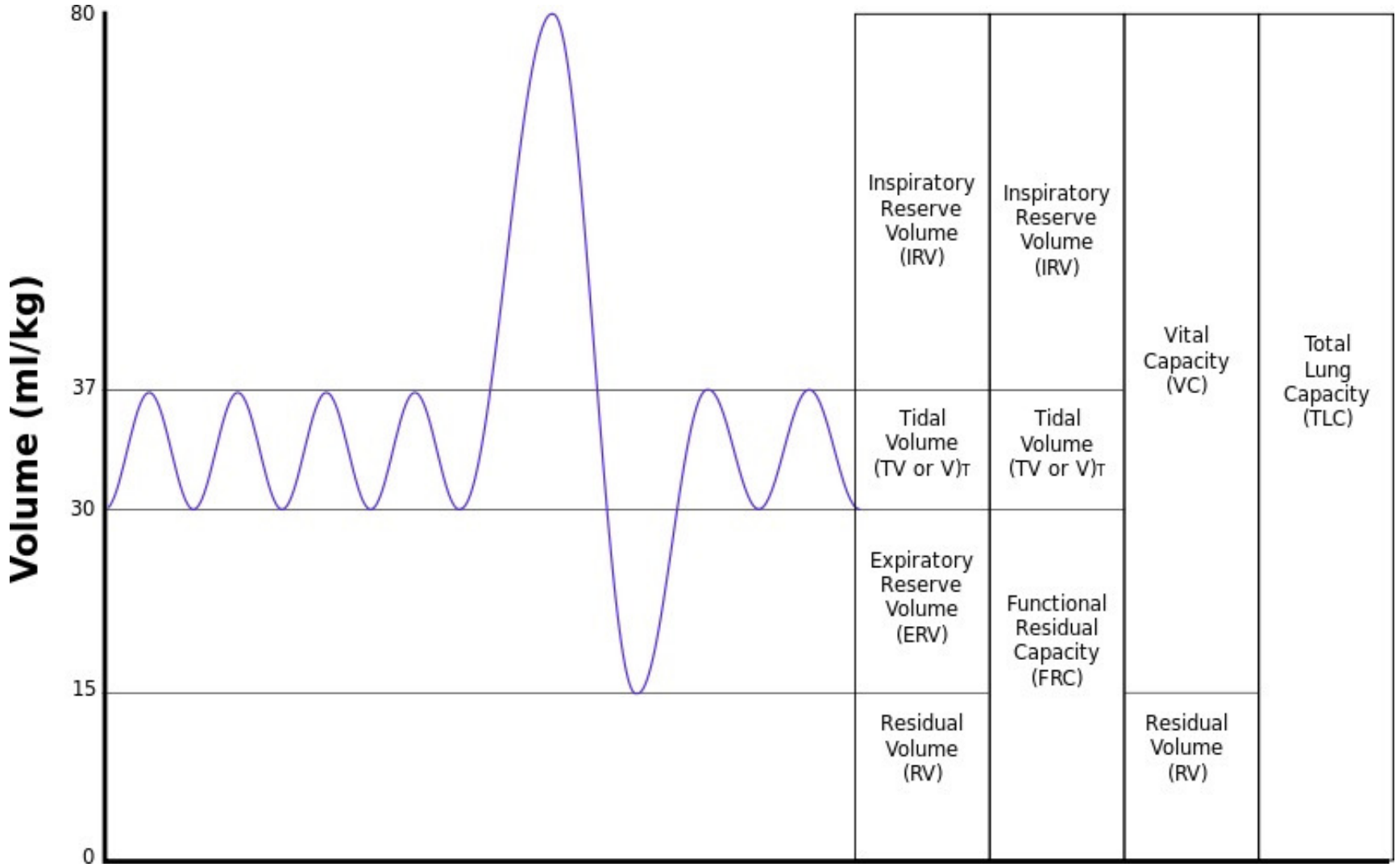
ARM ERGOMETER STRESS TEST

- **Assess cardiovascular and pulmonary system response to exercise**
- **Steady-state graded multi-stage test**
  - Extent of physical conditioning or deconditioning
  - Safe levels of daily exercise
  - Use to monitor during therapy

PULMONARY FUNCTION TESTS (PFT'S)

- Spirometry – maximal inhalation followed by rapid exhale
  - FEV1- forced expiratory volume in 1 second
  - Forced vital capacity (FVC)
  - FEV1/FVC ratio
  - Maximum voluntary ventilation (MVV) (calculated from FVC)
- Lung Volumes

Pellegrino et al (2005)


Volume (ml/kg)
80
37
30
15
0
Inspiratory Reserve Volume (IRV)
Tidal Volume (TV or V)T
Expiratory Reserve Volume (ERV)
Residual Volume (RV)
Inspiratory Reserve Volume (IRV)
Tidal Volume (TV or V)T
Functional Residual Capacity (FRC)
Vital Capacity (VC)
Residual Volume (RV)
Total Lung Capacity (TLC)

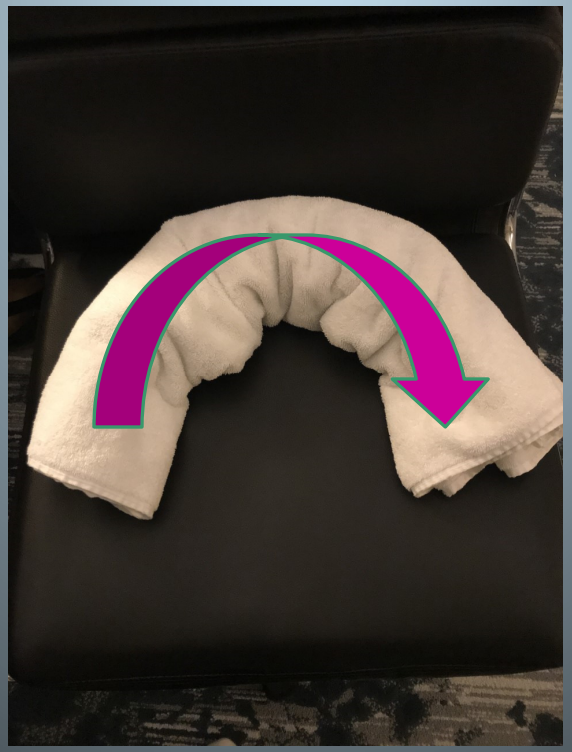
OBJECTIVE 3

- Examine the impact of wheelchair positioning on cardiopulmonary function

POSTURAL SUPPORT?

OPTIONS FOR IMPROVING CARDIOPULMONARY FUNCTION THROUGH BIOMECHANICAL SUPPORT OF BREATHING

- **Improve chest wall expansion**
  - Lumbar horizontal roll – promotes A/P expansion
  - Thoracic vertical roll – stabilizes spinal column
  - Thoracic horizontal roll – promotes A/P
  - Ischial roll – promotes anterior pelvic tilt
    - need active thorax, don't use if sensory diminished



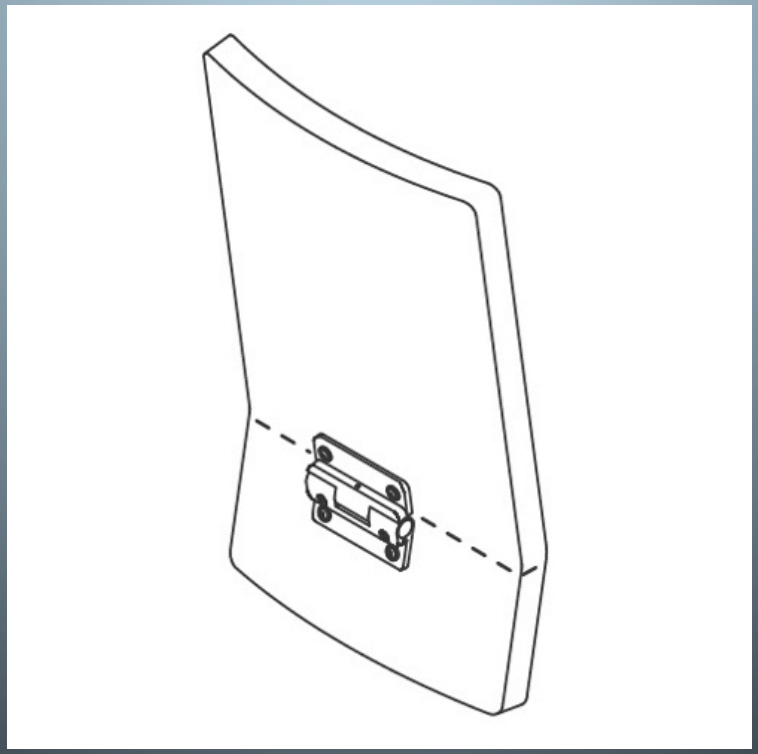
IMPACT OF POSITIONING ON PULMONARY FUNCTION

Jay Encompass Seat Back

Hardware with multiple planes of adjustment

http://www.sunrisemedical.com/seating-positioning/jay/wheelchair-backs/encompass-back

IMPACT OF POSITIONING ON PULMONARY FUNCTION



IMPACT OF POSITIONING ON PULMONARY FUNCTION

Roho Agility back

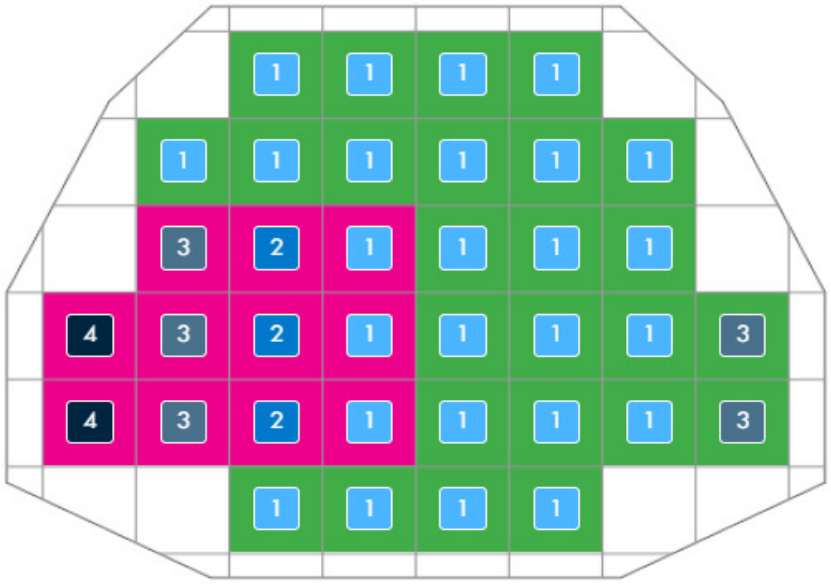
https://permobilus.com/product/rohoagilityminimum-contour-back-system/

ROHO AGILITY CUSTOM SPINAL DEFORMITY

Login Register

AGILITY Custom Minimum Contour
14” Width x 10” Height x 3” Depth

inch cm



Bottom

Step 3

Drag or Click to Create Adjustable Air Compartments

AGILITY Custom Backs give you the option(s) to create separate adjustable air compartments. Please select and name the compartments needed for this AGILITY Custom Back. To create air compartments, drag-select by holding down the mouse button and dragging the cursor to another cell location. Then name the compartment. Limit 7 compartments.

Compartments

L lateral

R side

NEXT

https://seating.custom.permobil.com/agility

CUSTOM MOLDED SEAT BACK

- Myelomeningocele
- Spinal Deformity
- Quickie 2, Emotion
- Invacare seat back

Mold using PRM created by Jon Beers, Blackburns, Tarentum, PA

MODIFICATION OF A MOLDED SEAT FOR A GROUP 3 POWER WHEELCHAIR

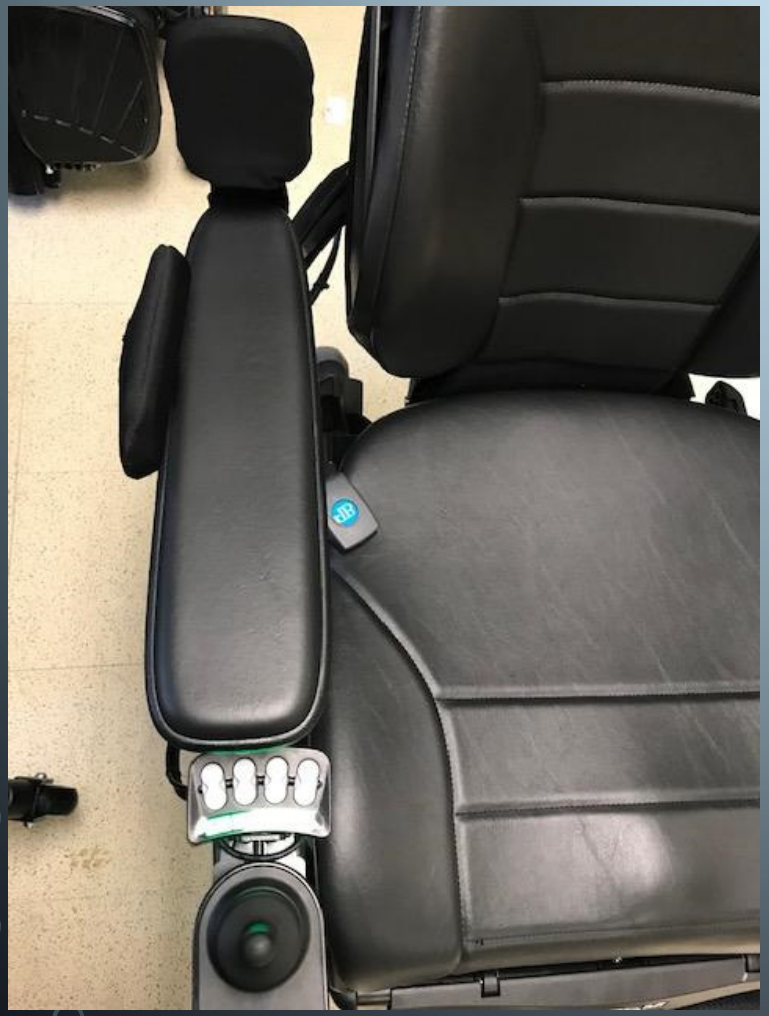
Diagnosis: Duchenne's MD, Quadriplegia, Nonischemic cardiomyopathy, L ventricular dysfunction w/ejection fraction 30%.

History of Present Condition: BIPAP at night for respiratory support. Was hospitalized for Wolf Parkinson syndrome, his heart rate to 250 bpm and underwent ablation, CD and feeding tube. Lost muscle strength after this.

Wheelchair: Permobil F3 power w/c with power tilt recline, elevating leg rests. Based on multidisciplinary evaluation, requires a custom molded seat and back.

- Based on a mat evaluation: Pectus excavatum, scoliosis, R pelvic obliquity (L hip down and R hip elevated), pelvic rotation and pectus excavatum. In wheelchair sitting has R lateral trunk lean and lacks adequate lumbar support to maintain lordosis/anterior pelvic tilt/spinal extension that would promote chest wall expansion and improve ventilation of his R lung. Stage 1 pressure area at waistline where his R lower lateral ribs collapses to the R elevated R hip.
- During clinical trial, found that supporting the posterolateral hip addressed the R pelvic obliquity. Found that providing lumbar and R thoracic support improved chest wall excursion (deeper breaths), increased SAO2 from 89 to 92, slowed respiratory rate and reduced pressure over his R lateral ribcage and waist.
- Because his trunk is correctable to a degree and he showed benefits to his pulmonary function and improved pressure relief to justify a **customized molded seat and back**.

UPPER EXTREMITY SUPPORT, ENCOURAGE EXTERNAL ROTATION



Benefits of Standing on Pulmonary Function

Rifton Prone Mobile Stander

https://www.rifton.com/products/standers/mobile-standers

OBJECTIVE 4

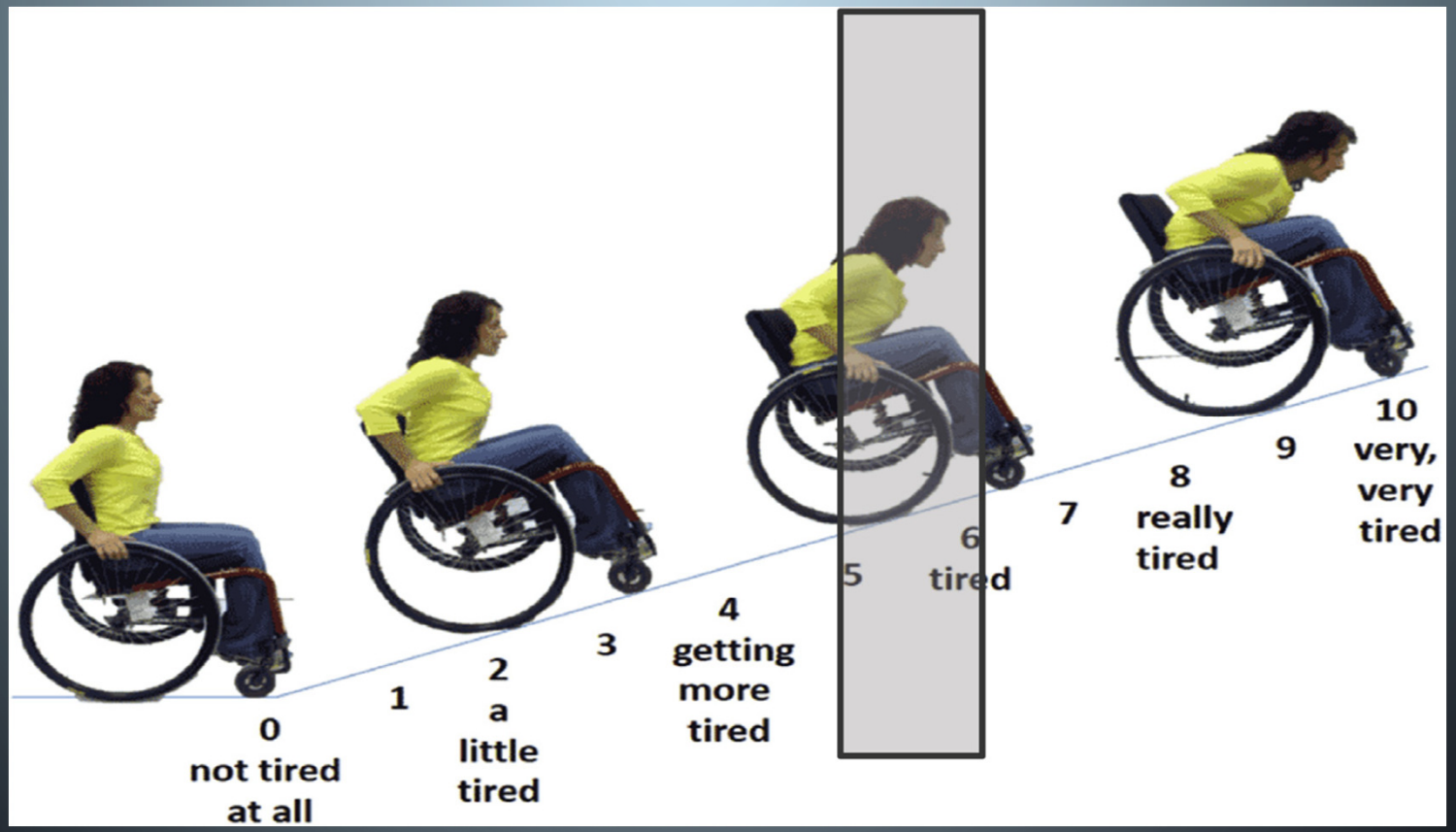
- Examine the impact of physical activity on cardiopulmonary function for adaptive athletes

BENEFITS OF CARDIOPULMONARY EXERCISE

- Cardiovascular (Central) Adaptations and Muscular (Peripheral) adaptations to exercise
  - Increased stroke volume
  - Increased VO2 max
- Endurance training = increase in slow twitch muscle fibres
  - Increase in capillary supply to skeletal muscle fibres
  - Increase in mitochondrial content in skeletal muscle fibres
  - Decreased use of glucose (carbs) for fuel and increase in fat metabolism
- Sprint training = increase in fast twitch muscle fibres
  - Increase in ability of muscles to handle lactate

Power SK HE. *Exercise Physiology. Theory and Application to Fitness and Performance.* 10th ed. New York: McGraw Hill Education; 2018.
Islam H, Townsend LK, Hazell TJ. Modified sprint interval training protocols. Part I. Physiological responses. *Appl Physiol Nutr Metab.* 2017;42(4):339-346.

EXERCISE PRESCRIPTION USING A GROUP-NORMALIZED RATING OF PERCEIVED EXERTION IN ADOLESCENTS AND ADULTS WITH SPINA BIFIDA



The shaded area represents a starting point for prescribing exercise intensity in people with myelomeningocele who achieved ventilatory threshold. Crytzer, T.M., Keramati, M., Anthony, S.J., Cheng, Y.-T. Robertson, R.J. and Dicianno, B.E. (2018),

WHEEL SCALE TO BORG SCALE CONVERSION FOR INDIVIDUALS WITH SB WHO ACHIEVED VENTILATORY THRESHOLD DURING EXERCISE STRESS TEST

WHEEL Scale RPE	1	2	3	4	5 Vpt	6	7	8	9	10
Borg Scale RPE	6-8	9-10	11	12	13 Vpt	14	15-16	17	18	19-20

Crytzer, T.M., Keramati, M., Anthony, S.J., Cheng, Y.-T., Robertson, R.J. and Dicianno, B.E. (2018),

HANDCYCLING

- Compared to wheelchair push rim, handcycling is energetically more efficient and less straining for the cardio-respiratory system with lower risk of injury of the shoulder joints due to less forces, use of larger muscles (e.g., lats, serratus.

Arnet U, van Drongelen S, van der Woude LH, Veeger DH. Shoulder load during handcycling at different incline and speed conditions. *Clin Biomech (Bristol, Avon).* 2012;27(1):1-6.

Basic energy sources (primary and secondary metabolic systems) that need to be trained?

- Aerobic (Oxidative Phosphorylation)
  - Primary source of training for road race due to long distance
    - Moderate intensity training in handcycle at 70% maximal oxygen consumption (VO_2)
- Anaerobic (Glycolysis)
  - Used for hills and sprint at end
  - High Intensity Interval Training (HIIT) training
    - Brief repeated bouts of near max exercise at 80-100% of heart rate max (HR_{max}) followed by short recovery.

Belloli M, Cheli F, Bayati I, Giappino S, Robustelli F. Handbike aerodynamics: wind tunnel versus track tests. *Procedia Eng.* 2014;72:750-755.

HANDCYCLING

- **Aerodynamics of handcycling that could impact race performance:**
  - Race handcycles reach velocities (higher than 50 km/h)
  - Drag force takes up majority of power consumption.
    - Aerodynamic drag is ~ 80% of total resistive force in road racing at 30 km/h and up to 94% in time trial competitions at 50 km/h
  - **Goal during racing is to reduce resistive force to improve cycling performance**

Belloli M, Cheli F, Bayati I, Giappino S, Robustelli F. Handbike aerodynamics: wind tunnel versus track tests. *Procedia Eng*. 2014;72:750-75

ASSESSMENT OF ATHLETE

- Physical testing and evaluation
  - Medical history/Training background/exercise history
    - Performance testing to assess physiological characteristics.
    - Graded maximal exercise stress testing (arm ergometry) to obtain VO2 max, VE, VCO2, RER, RPE, O2 pulse
    - Wingate test (using arm ergometry)
    - Manual muscle testing (strength testing) OR Biodex -test isokinetic strength of all major muscles, or hand- held dynamometry
    - Sensory testing secondary to neurological impairment and to determine classification (IPC required for paraplymic contender)
    - Balance testing (torso balance in sitting and righting reactions) secondary to neurological impairment and to determine classification and position of backrest (back rest that is lower promotes the use of gravity for positioning and provides increased stability to the torso.

PHYSIOLOGICAL TESTS

- Graded maximal exercise stress test (*per* ACSM guidelines) to determine bodies ability to utilize oxygen during maximal exercise stress
    - **VO2max**, VCO2, RER, RPE
    - **Blood lactate** to determine accurate VO2max
    - **EKG** to rule out heart condition and determine cardiac response to exercise
    - **Maximal respiratory frequency/minute ventilation** to assess ability of the pulmonary system to respond to maximal exercise
    - **Average crank rate**
    - **Peak crank rate** at various levels to determine potential function on the road
    - Power output
  - Wingate (alternate aerobic test)
    - anaerobic capacity for sprints
    - anaerobic power output
- **Dynamometry** to measure isokinetic strength in traps, deltoids, triceps, biceps, wrist extensors and flexors

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APPENDIX

- Documentation of Justification
  - TUG/BORG/HR/O2 – Long version
  - TUG/BORG/HR/O2 – Short version
  - Molded seat Modification Power chair
  - Modification of lateral support
  - Power tilt/recline general justification

TUG/BORG/HR/O2 – LONG

- **<u>Functional Mobility</u>: The Timed Up & Go Test took *** seconds indicative of non-functional walking speed and Helen being at risk for falls.**
  - *The results of Shumway-Cook's study found that the TUG is a sensitive and specific measure [Interrater reliability (ICC) = 0.98], for identifying community-dwelling adults who are at risk for falls. The authors found that community-dwelling older adults who took longer than 13.5 seconds were correctly predicted as fallers 80% of the time and correctly predicted as non-fallers 100% of the time, with an overall prediction rate of 90% of the time.* (Shumway-Cook, A., S. Brauer, and M. Woollacott, Predicting the probability for falls in community-dwelling older adults using the Timed Up & Go Test. *Physical Therapy*, 2000. **80**(9): p. 896-903).
- **Vitals: Oxygen saturation rate and heart rate at rest or pre-activity was xx%, xx bpm and post-activity was xx%, xx bpm.**
- **Perceived Exertion: He/She rated this activity as a xx on the Borg Perceived Exertion Scale (score ranges from 6-20, with 20 the highest level of exertion).**
  - ***Perceived exertion*** *is how hard you feel your body is working. It is based on the physical sensations a person experiences during physical activity, such as increased heart rate, increased breathing rate, sweating, and muscle fatigue (Borg, 1998). A high correlation exists between a person's perceived exertion rating x 10 and the actual heart rate during physical activity (Borg, 1998). For example, if a person's rating of perceived exertion (RPE) is 12, then 12 x 10 = 120; so the heart rate should be approximately 120 beats per minute. This calculation is an approximation of heart rate, and the actual heart rate can vary quite a bit depending on age and physical condition. The Borg scale is also the preferred method to assess intensity among those individuals who take medications that affect heart rate or pulse."*
    (http://www.cdc.gov/physicalactivity/everyone/measuring/exertion.html, Accessed 10/11/2011)

TUG/BORG/HR/O2 – SHORT

- **Functional Mobility**: The Timed Up & Go Test took *** seconds indicative of non-functional walking speed and XXX being at risk for falls. Oxygen saturation rate and heart rate at rest or pre-activity was xx%, xx bpm and post-activity was xx%, xx bpm. He/She rated this activity as a xx on the Borg Perceived Exertion Scale (score ranges from 6-20, with 20 the highest level of exertion).

MODIFICATION OF LATERAL SUPPORT TO GROUP 3 CHAIR

DIAGNOSIS: Late Effect Acute Polio, Post laminectomy Syndrome Lumbar, Type II diabetes, sleep apnea, s/p left (L) knee osteotomy. As a result of these conditions XXX has significant limitations in all mobility needs both in the home and community. Client uses a Q6 Edge power wheelchair with power tilt, recline power elevating leg rests, and seat elevator. XXX requires modification of custom-made lateral support due to convexity of the L trunk secondary to levoscoliosis and low trunk tone. The following modification is required:

SPECIFICATION/JUSTIFICATION: Left side custom thoracic pad mounted to the armrest with removable cover 1" deep, 10" high, 2" thick. The custom created left thoracic lateral is required to capture and provide support to ribs 7,8,9 along the convexity of her trunk in order aid in preventing further collapse of the chest wall, provide proprioceptive cueing for upright posture, and promote a more open chest wall on the concave side. The padded, wide 10" thoracic pad is also designed to disperse pressure over a larger area of her lateral rib cage to prevent skin breakdown and soft padding to allow chest wall expansion.

POWER TILT AND RECLINE ON A GROUP 3 CHAIR - GENERAL

Power tilt-in-space, recline, and elevating leg rests are necessary for management of spasticity, pressure relief, edema management and dressing. The recommendations are based on the fact that XXX spends XXX hours per day in the wheelchair and XXX is unable to conduct an independent pressure relief maneuver due to UE weakness and impaired coordination. Without the ability to independently change positions XX would be at greater risk of skin breakdown, pain, fatigue and **spinal deformities such as kyphosis and scoliosis that can affect breathing and swallowing**. The Tilt-in-Space promotes independent pressure relief and distribution when used in combination with a pressure relief cushion. The Tilt-in-Space also promotes independent positioning and prevents the occupant from sliding down and out of the wheelchair.

The recline is needed to open up the hip to back angle and gain gravity assisted positioning with the combination of tilt and recline. **The recline can also help to improve chest wall expansion and respiration by opening up the chest wall.** The use of power recline without power tilt would be contraindicated because the use of recline alone would increase sheer forces under the buttocks, legs and back and it could elicit spasticity and lead to pressure wounds, poor positioning and the potential to slide out of the chair.