Physical Activity for Brain and Body:

Considerations of dosage to maximize quality of life

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Objectives:

1. Summarize the physical changes of aging that impact the older adult’s ability to stay active.

2. Outline a plan for physical activity in older adults to prevent sedentary changes in both cognitive and physical fitness.

An INTENSE schedule...
An ambitious schedule....

- Aging statistics
- Physical and cognitive impairments
- Obligatory changes with aging
- Body-brain connection
- Dosage, guidelines, and recommendations
- Personalization
- Debunking myths
- Applying the latest science

The physiology of aging: physical

Slower nerve conduction velocity
Reduced maximum heart rate
Reduced maximal lung capacity
Loss of Type II muscle fibers
Reduction in motor units (neuromuscular jct.)
Reduction in skin elasticity
The physiology of aging: cognitive*

- Slower cognitive processing – response speeds
- Slower nerve conduction velocity
- Presbycusis (hearing)
- Reduced attentional reserves

The FUNCTIONAL sequela of aging: physical

- Strength: up from floor
- Stiffness: up *each time* from sitting
- Strength/endurance: stairs/hills
- Endurance: distance or higher-speed walking
- Strength: carrying loads/packages
- Balance: uneven surfaces, darkness, speed

The FUNCTIONAL sequela of aging: cognitive

Reaction speed, distraction tolerance, memories
1. Falls
2. Car accidents
3. Financial management
4. Pathfinding
5. Instrumental ADL inefficiencies: errands, meals
6. Work related mistakes
7. Productivity errors/reduction
Functional importance of managing attention
Dual task intolerance can be implicated in:

• Falls in the elderly
• ADL dependence
• Driving safety
• Workplace safety
• Aspiration pneumonia
• Capacity to form new memories

Body-brain connection

• Body (through intense exercise) feeds brain
• Brain releases neurotransmitters
• Brain consolidates memories (motor, facts)
• Brain improves skill
• Body translates and refines skill

Parameters of Physical Fitness:

**Power**: The ability to produce force in a defined or constrained period of time

**Strength**: Force that can either be produced by or tolerated within the musculoskeletal system. Requires neuromuscular recruitment and tensile structural capacities.

**Muscular Endurance**: The ability to continue to recruit and contract the appropriate muscles for an activity that last for more than 20 repetitions.

Parameters of Physical Fitness:

• **Cardiopulmonary Endurance**: Sustained aerobic activity (oxygen catalyst) supplying energy to and removing waste from the muscular system through cardiac and pulmonary systems.

• **Balance**: The ability to statically or dynamically keep the center of mass within the base of support while engaging in transport/mobility, daily living, stability, vocational, avocational, or sport-related function.

• **Flexibility**: The capacity to move or be moved through an anatomically safe range of motion as needed to function painlessly, perform, compete or survive.
Parameters of Attention:

**Focused**: respond to specific stimuli (auditory, visual, or tactile).

**Sustained**: maintain a consistent response during a continuous and repetitive activity

**Selective**: maintain a behavioral or cognitive set in the context of distracting or competing stimuli

**Alternating**: demonstrate mental flexibility to shift attention focus

**Divided**: respond concurrently to multiple tasks or demands

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**Attentional and Procedural networks**

**Primary Task**: Motor task in solitude

**Secondary Task**: Manual, Auditory, Visual, Cognitive

**Decrease in Performance**: Shared attentional resources

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**Distractibility + dual task intolerance**

**Inability (identified area for potential growth) to:**

Focus on a single task
Endure focus
Alternate between stimuli
Filter insignificant information
Prioritize between competing stimuli
Divide attention when both are needed + shared
Dual Task Testing: Measure abilities

Measurement of interference of one task due to concurrent performance of a second, yielding a pattern of performance deterioration of one or both tasks

Dual task cost: \[ \text{DUAL} - \text{SINGLE} \times 100 \]

Physical or Cognitive Wellness...

Which would you choose, if you had to pick one?

...what if you do not have to choose?

Improving body systems through exercise

A common link in comorbidities...

- Alzheimer’s disease
- Parkinson’s disease
- Cardiovascular disease, including stroke
- Diabetes and diseases of endocrine systems
- Arthritis (rheumatoid)
- Diseases of intestinal health: IBS, colitis, Crohn’s

...is inflammation
Exercise on Inflammation, vascular

An Acute Bout of Aquatic Treadmill Exercise Induces Greater Improvements in Endothelial Function and Postexercise Hypotension Than Land Treadmill Exercise: A Crossover Study

Objective

The purpose of the study was to compare acute bouts of aquatic treadmill (AT) and land treadmill (LT) exercise on flow-mediated dilation (FMD), postexercise blood pressure, plasma nitrate+nitrite, and serum nitrotyrosine in untrained, prehypertensive men.

Design

A randomized, crossover design, 10 trained, posthypertensive men completed bouts of AT and LT on separate days. Flow-mediated dilation was measured pre-exercise and 1 h postexercise. Blood samples were obtained pre-exercise and immediately postexercise and analyzed for plasma nitrate/nitrite and serum nitrotyrosine. A multiplicity-based inference approach to inference was used for statistical analysis.

Results

A positive clinical benefit increase in flow-mediated dilation (1.1%, 95% confidence interval) was observed following AT exercise compared to LT exercise.

Exercise on Immune System

Neutrophil and Monocyte Bactericidal Responses to 10 Weeks of Low-Volume High-Intensity Interval or Moderate-Intensity Continuous Training in Sedentary Adults

Abstract

Neutrophils and monocytes are key components of the innate immune system that undergo age-associated declines in function. This study compared the impact of high-intensity interval training (HIIT) and moderate-intensity continuous training (MCT) on immune function in sedentary adults. Twenty-seven (43 ± 11 years) healthy sedentary adults were randomized into two arms of either a HIIT (90% maximum heart rate) or MCT (70% maximum heart rate) group training program. Aerobic capacity (VO2peak), neutrophil and monocyte bacterial phagocytic and oxidative burst, cell-surface receptor expression, and systemic inflammation were measured before and after the training. Total exercise time commitment was

Exercise on Psychologic Function

Exercise Leads to Better Clinical Outcomes in Those Receiving Medication Plus Cognitive Behavioral Therapy for Major Depressive Disorder

Abstract

The aim of this study is to investigate the effects of exercise as an add-on therapy with antidepressant medication and cognitive behavioral therapy (CBT) on treatment outcomes in low- to high-functioning depressive disorder (MDD) patients. We also explored whether exercise reduces the residual symptoms of depression, notably cognitive impairment and poor sleep quality, and aimed to identify putative biochemical markers related to treatment response.

Exercise on Cognition

The Influence of Exercise on Cognitive Abilities

Abstract

Scientific evidence based on neuroimaging approaches over the last decade has demonstrated the efficiency of physical activity improving cognitive health across the human lifespan. Aerobic fitness appears age-related loss of brain tissue during aging, and enhances functional aspects of higher-order regions associated in the control of cognition. More active or higher-fit individuals are capable of allocating greater attentional resources toward the environment and are able to process information more quickly. These data are suggestive that aerobic fitness enhances cognitive strategies enabling improved performance on tasks that are thought to be of importance to everyday cognitive function. The current study aimed to evaluate the effects of a 10-week, aerobic exercise intervention on cognitive performance. The results of the study showed that participants in the exercise group performed better on the cognitive tasks compared to the control group. The findings suggest that aerobic exercise can be an effective intervention for improving cognitive performance in older adults.
Exercise as a cognitive intervention?

What if we COMBINED physical exertion with cognitive stimuli?

Dosage, guidelines, and recommendations

**STRENGTH**
- **Frequency:** 2-3 times per week
- **Repetitions:** 8-12 per set
- **Sets:** 2-3 per exercise
- **Intensity:** 8-12 reps  PROPER FORM
  - > 12 reps, increase weight 5 pounds.
  - < 8, decrease weight 5 pounds.
Core* Strength Exercise Dosage

- Daily to 5x/week
- 20+ repetitions in a set (or enduring for time)
- Multidirectional
- Considerations of medical history

*RECOVER with stretch to reduce tension

Dosage, guidelines, and recommendations

BALANCE

- **Frequency**: 5-7 times per week
- **Repetitions**: 5-10 per set
- **Sets**: 2-3 per exercise
- **Intensity** - sufficient to create a safe and recoverable loss of balance
- **Comprehensive** – addressing each aspect of balance

<table>
<thead>
<tr>
<th>VISION</th>
<th>BASE</th>
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<tbody>
<tr>
<td>EYES CLOSED</td>
<td>ONE LEG</td>
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<tr>
<td>HEAD NODDING</td>
<td>TANDEM</td>
</tr>
<tr>
<td>HEAD ROTATION (SIDE-SIDE)</td>
<td>FEET STAGGERED</td>
</tr>
<tr>
<td>OBSTRUCTION/DISTRACTION</td>
<td>FEET TOGETHER</td>
</tr>
<tr>
<td>ARMS LENGTH REACH</td>
<td>FIRM</td>
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<tr>
<td>SIT TO STAND</td>
<td>CUSHIONED</td>
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<tr>
<td>REACH BEYOND ARM'S LENGTH</td>
<td>UNEVEN</td>
</tr>
<tr>
<td>STOOPING/FLOOR RETRIEVAL</td>
<td>SLICK</td>
</tr>
<tr>
<td>MOTION</td>
<td>SURFACE</td>
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</table>

Espy, D
Used with personal permission
Systems of Balance

<table>
<thead>
<tr>
<th>Biomechanical Constraints</th>
<th>Stability Limits / verticality</th>
<th>Anticipatory Postural Adjustments</th>
<th>Postural Responses</th>
<th>Sensory Orientation</th>
<th>Stability in Gait</th>
</tr>
</thead>
</table>

Dosage, guidelines, and recommendations

**ENDURANCE**

- **Frequency**: A minimum of 3-5 times per week
- **Intensity**: 60-90% of maximum heart rate
- **Time**: 20-30 minutes minimum (accumulated)
- **Type**: Aerobic (run, jog, elliptical, brisk walk, bike, stairs, etc.)
- **Engaged**: Enjoyable aerobic activities

**Key to attention gains through exercise?**

Personalization: **F.I.T.T.E.**

- **Frequency**: Days per week or times/day
- **Intensity**: % of max. heart rate, load, or skill
- **Time**: Consecutive minutes minimum
- **Type**: Mode of exercise (run, swim, weights, rowing, bike, etc.) or competition (tennis, golf)
- **Engaged**: Enjoyable for regular participation

Dosage, guidelines, and recommendations

**PHYSICAL ACTIVITY OVERVIEW**: (brain and body)

- Moderately intense aerobic 30 min/day 5x/wk
  **OR**
- Vigorous intensity aerobic 20 min/day 3x/wk
  **AND**
- 8-10 Weight Exercises with 8-12 reps 2x/wk
Debunking myths

• Falling is a natural part of aging
• Cannot improve balance
• Memory declines only as a function of aging
• Strength declines only as a function of aging
• Cannot gain strength after _____
• People over _____ should not ______

Debunking the myths....

• Which of the following are true?

Debunking the myths....

• We lose 10% of our muscle every year after 60...
• People over 50 years old cannot get stronger...
• Fat replaces muscle as you age...
• Using resistance or weights is dangerous...
• You cannot do resistance work with arthritis...

• Others?

Debunking the myths....

• We lose 10% of our muscle every year after 60...
• People over 50 years old cannot get stronger...
• Fat replaces muscle as you age...
• Using resistance or weights is dangerous...
• You cannot do resistance work with arthritis...

ALL OF THESE ARE FALSE!!!!!
American College of Sports Medicine

Minimize the physiological effects of a sedentary lifestyle
Increase active life expectancy by modifying chronic disease/comorbidities
Combine aerobic, strengthening, balance and flexibility exercises
Combinations (strength, endurance) > any form of training alone
Higher-intensity training programs are more effective
Consistency > intensity
Benefits of a single exercise session are relatively short-lived

Applying the latest science:
Physical

High intensity interval training

• Short bursts of 80-90% of maximal capacity (15-45 seconds is typical)
• Interspersed with 2-3x the duration of 25-40% effort for recovery

High Intensity Interval Training (HIIT)

Researched in:
• Weights
• Swimming
• Sprinting (running, cycling)
• Ergometry

Specific benefits of HIIT:
• Less time in training
• Quicker recovery
• Fewer injuries
Optimizing Recovery Time

- Nutrition
- Sleep
- Hydration
- Thermal
- Exercise (active recovery)
- Massage

Exercise principles

- Overload
- Progression
- Adaptation
- Use and Disuse
- Specificity

Optimal Strength “Recovery” Dosage

- Rest & Frequency
- Between sets
  - Circuit training, 15-30 seconds
- Between workouts
  - (2-3x/week)

Applying the latest science: Cognition

- Person-specific (mode of cognitive stimulation)
- Cognitively stimulating – not reminiscing
- Variable
- Novel
- Successful*
- Intensity?
Learning, attention and memory
Brain health...

Dual Task HIIT

- Immediate feedback – scoring, gaming, competing
- Evidence-based using physical + cognitive input
- Quantified single task
- Quantified DT in physical and cognitive output
- Variety of cognitive stimuli addressing all aspects
- Increased expectations of physical + cognitive

SUMMARIZING:
What have we learned?

- Aging statistics
- Physical and cognitive impairments
- Obligatory changes with aging
- Body-brain connection
- Debunking myths
- Applying the latest (and future) science
BONUS MATERIAL for continued learning

See MTGEC website for added materials

http://health.umt.edu/mtgec/Annual-Conference.php

Core strengthening

Core strengthening
Core strengthening

Recovery with aging

• Exhaustive and prolonged exercise is associated with higher degree of oxidative stress. Remains elevated 48 hours later

  (Martarelli, J Sports Med and Phys Fit, Mar 2009)

Overload

• Higher than normal stressors in resistance, repetitions, or range.

• The “imposed demands” of the SAID principle

Progression

A logical and systematic increase in overload that can be introduced over an appropriate schedule.

• Considers time and workload
• Considers recovery and response
• Allows for repair and therapeutic dosage
Adaptation

The process of acclimating to increased or decreased physical demands in the form of:

- Resistance
- Repetitions
- Endurance (time/duration)
- Environment (conditions of temperature, wind, altitude, etc)
- Skill

- Considers the decreasing effect of repeating the same exercise routine.

Use and Disuse

Skeletal and cardiac tissue hypertrophies with use and atrophies with disuse.

- Applies to:
  - Tensile capacity (force)
  - Endurance
  - Neuromuscular fatigability
  - Energy AND Oxygen storage and delivery systems

Specificity (SAID)

- “Practice makes perfect.”
- Relates to cross training and carryover
- Myths about SAID exist in the need for strength in skill-based sports

Considerations of injury prevention: Specific modifications

- Running 1-20 miles a week @6-7 mph(2-5 days a week)=lower all cause mortality
- Higher mileage, faster paces and more frequent did not correlate to better survival (Lee 2012)
MEASUREMENT in DUAL TASK

Evidence-based treatment is based on:

- Establishing a diagnosis through examination
- Using tests and measures of function, impairment, and participation
- Re-examining patients to ensure that they are improving
- Challenging balance in a task-specific manner that is consistent with tested impairments

C-TUG

- TUGO: Stand, walk 3 m, return and sit
- Secondary task: subtract by 3 from a random number between 66 and 100.
- Measurements: times for walking in single and dual task
- Cut-off: 15 sec discriminate subjects with a history of falls
- Limitation: Cognitive task difficulty varies based on education, math ability.*

Expose and test EACH as SINGLE, prior to DUAL

Modified Ambulatory Trail Making Test

- Measures the ability to alternate attention
- Measures response speed and visual scanning
- Combines agility/balance

Cognitive Four Square Step Test: CFSST

- 6 words presented. 1 minute to memorize. Recheck words. Say words aloud as moving through the FSART, relying on working memory. since the pattern of movement is described and then completed during the test, requiring memory of the required directional pattern.
- DT with the simultaneous recall and reiteration (aloud) of the words, during the FSST = FSART.
- % words recalled
- Remembered sequence with direction change
- DT cost in terms of %, a function of time loss
Screening for Cognitive Impairment and gait abnormalities

- Mini Mental Status Exam (MMSE)
- Montreal Cognitive Health Assessment (MOCHA)
- Mini-cog
- St. Louis University Mental Status (SLUMS)
- Gait speed (> 1.0m/sec)

Stroop Test

Look at the list below and say the **COLOR** not the word.

- **YELLOW**
- **BLACK**
- **PURPLE**
- **ORANGE**
- **BLUE**
- **RED**
- **GREEN**

Dual task effects on gait speed:

Comfortable

<table>
<thead>
<tr>
<th>Task</th>
<th>Cut-off (s)</th>
<th>Sn (%)</th>
<th>Sp (%)</th>
<th>+LR</th>
<th>-LR</th>
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<tbody>
<tr>
<td>Single Task</td>
<td>11.3</td>
<td>70</td>
<td>45.6</td>
<td>1.29</td>
<td>0.66</td>
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<tr>
<td>Verbal Fluency</td>
<td>14.7</td>
<td>60</td>
<td>48.5</td>
<td>1.17</td>
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<td>Subtraction of 3</td>
<td>16.8</td>
<td>55</td>
<td>64.7</td>
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<td>Manual Task</td>
<td>14.9</td>
<td>65</td>
<td>52.9</td>
<td>1.38</td>
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### Dual task effects on gait speed: Maximal

<table>
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<tr>
<th>Task</th>
<th>Cut-off (s)</th>
<th>Sn (%)</th>
<th>Sp (%)</th>
<th>+LR</th>
<th>-LR</th>
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<td>75</td>
<td>33.8</td>
<td>1.13</td>
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<td>12.7</td>
<td>70</td>
<td>52.9</td>
<td>1.49</td>
<td>0.57</td>
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<tr>
<td>Subtraction of 3</td>
<td>14.0</td>
<td>65</td>
<td>61.8</td>
<td>1.70</td>
<td>0.57</td>
</tr>
<tr>
<td>Manual Task</td>
<td>11.5</td>
<td>70</td>
<td>44.1</td>
<td>1.25</td>
<td>0.68</td>
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### Dual task effects on (backward) gait speed

<table>
<thead>
<tr>
<th>Task</th>
<th>Cut-off (s)</th>
<th>Sn (%)</th>
<th>Sp (%)</th>
<th>+LR</th>
<th>-LR</th>
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<tr>
<td>Single Task</td>
<td>28.8</td>
<td>70</td>
<td>53.9</td>
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<td>Verbal Fluency</td>
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<td>44.1</td>
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<tr>
<td>Manual Task</td>
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<td>70</td>
<td>44.1</td>
<td>1.25</td>
<td>0.68</td>
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### Dual task effects on gait speed: TUG

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<th>Cut-off (s)</th>
<th>Sn (%)</th>
<th>Sp (%)</th>
<th>+LR</th>
<th>-LR</th>
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<tbody>
<tr>
<td>TUG</td>
<td>12</td>
<td>41</td>
<td>73</td>
<td>1.57</td>
<td>0.8</td>
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<td>TUG-cog</td>
<td>14.7</td>
<td>76.5</td>
<td>73.7</td>
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### Effects of Digit Span on Gait

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<tr>
<th>Digit Domain</th>
<th>Gait Parameter</th>
<th>Test 1 X (SD)</th>
<th>Test 2 X (SD)</th>
<th>t-Test Value</th>
<th>Effect Size (d)</th>
<th>ICC (95% CI)</th>
<th>SRM</th>
<th>MDC</th>
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<tbody>
<tr>
<td>Rest</td>
<td>Speed (m/s)</td>
<td>0.92±0.15</td>
<td>0.94±0.12</td>
<td>-2.71</td>
<td>-22</td>
<td>0.02±0.04</td>
<td>0.06</td>
<td>0.10</td>
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<tr>
<td></td>
<td>Stride length (m)</td>
<td>1.12±0.15</td>
<td>1.12±0.12</td>
<td>-0.96</td>
<td>-24</td>
<td>0.01±0.04</td>
<td>0.05</td>
<td>0.14</td>
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<tr>
<td></td>
<td>Cadence (steps/min)</td>
<td>98.17±3.75</td>
<td>100.36±3.13</td>
<td>-2.57</td>
<td>-01</td>
<td>0.08±0.04</td>
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<tr>
<td>Rhythms</td>
<td>Swing percentage (%)</td>
<td>33.8±3.32</td>
<td>33.8±3.32</td>
<td>0.07</td>
<td>24</td>
<td>0.01±0.04</td>
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<td>0.20</td>
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<tr>
<td></td>
<td>Step time (s)</td>
<td>1.24±0.06</td>
<td>1.21±0.14</td>
<td>-0.87</td>
<td>-07</td>
<td>0.02±0.04</td>
<td>0.37</td>
<td>1.02</td>
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<tr>
<td></td>
<td>Initial control</td>
<td>0.12±0.03</td>
<td>0.11±0.03</td>
<td>2.22</td>
<td>0.01</td>
<td>0.01±0.04</td>
<td>0.04</td>
<td>0.40</td>
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<table>
<thead>
<tr>
<th>Digit Domain</th>
<th>Gait Parameter</th>
<th>Test 1</th>
<th>Test 2</th>
<th>Wilcoxon Signed Rank Test</th>
<th>Test 1 vs Test 2 P-Value</th>
<th>Effect Size (d)</th>
<th>SRM</th>
<th>MDC</th>
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<tbody>
<tr>
<td>Treadmill</td>
<td>S2 stride length (m)</td>
<td>0.94±0.04</td>
<td>0.98±0.06</td>
<td>0.04±0.04</td>
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<td>0.04</td>
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<tr>
<td></td>
<td>S2 stride time (s)</td>
<td>0.84±0.03</td>
<td>0.86±0.04</td>
<td>0.04±0.04</td>
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<td>0.04</td>
<td>0.04</td>
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<tr>
<td>Asymmetry</td>
<td>S2 stride length asymmetry</td>
<td>0.82±0.02</td>
<td>0.82±0.02</td>
<td>0.04±0.04</td>
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<td>0.04</td>
<td>0.04</td>
<td>0.04</td>
</tr>
</tbody>
</table>
Effects of Stroop on Gait

Effects of mobile phone on Gait

Dual Task Cost (DTC)

\[
DTC = \frac{(DT - ST)}{ST} \times 100
\]

ST: Time to assemble and package widget = 78 sec
DT: Pressure gauge + clock
DT: Time = 115 sec

115 - 78 = 37 sec
37/78 \times 100 = 49%

Clinical application of the dual-task taxonomy: the modalities

- COGNITIVE*
- MANUAL
- AUDITORY
- VISUAL
Intervention across four modalities of concurrent tasks: Progression

Increasing complexity of primary and/or secondary tasks

Increasing novelty of primary and/or secondary tasks

Functional demands of the person’s environment
Home, work, avocation, sport

Psychological response to error/need for success

Multi-task – tolerance, expectations, functional demand

References


References

- Soo Ji Kim, Sung-Rae Cho, Gyu Eul Yeon. The Applicability of R...
References

- Fioriio E. et. al. Dual Task Performance: a comparison between healthy elderly individuals and those c PD’s. Fisioter. 2015; 28 (2).