MOVEMENT & THE MIND: THE SIGNIFICANCE OF DUAL TASK PERFORMANCE IN AGING INDIVIDUALS

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JULY 14TH, 2017
EMORY UNIVERSITY DIVISION OF PHYSICAL THERAPY

OBJECTIVES

- Discuss the role of executive function in motor performance
- Relate the effects of aging on the brain to cognitive-motor performance
- Discuss theories of cognitive flexibility and prioritization as it relates to dual task performance
- Demonstrate the relationship between impaired dual task performance and functional ability
- Summarize the evidence on the impact of exercise on cognitive-motor performance in older individuals
- Propose recommendations for developing effective dual task training strategies in older individuals
- Review novel intervention studies in the field of DT training for the aging population
- Review various outcome measures that assess motor cognitive capabilities
- Discuss strategies to implement effective dual task interventions into clinical practice

OPPORTUNITY

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PREPARING FOR THE POPULATION SHIFT

- The 85+ population is projected to triple from 6.3 million in 2015 to 14.6 million in 2040.
- By 2030 the population of people over 65 is anticipated to double.
- By 2050, almost half of people who have reached 65 will reach 90.

(Administration on Aging, Aging trends page.

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What does successful aging mean to you?
SUCCESSFUL AGING

Minimize disability  Active engagement (participation)
Successful Aging
High mental and physical function  Positive spirituality

CONTINUUM OF COGNITIVE DISORDERS

Normal Cognitive Aging
Healthy cognitive function
15-30% older individuals

Mild Cognitive Impairment

Irreversible Major Cognitive Impairment (Dementia)

2% - 7% 20% - 80% 37% - 90%
THE AGING BRAIN & STRUCTURAL CHANGES

- Cortical degeneration correlated with a decline in executive function (1, 13).
- Susceptible regions impacting dual task performance:
  - Supplementary motor area, frontal eye fields, prefrontal cortex (dorsolateral prefrontal cortex), cerebellum
  - White matter changes: Corpus callosum, axonal degeneration
  - Vascular supply decreases 10-15%
- Reduction in neurotransmitter activity: ACH, DA, 5HT, NE
- Decrease in nerve conduction velocity ~ 15% by age 70

ROLE OF COGNITION & MOTOR FUNCTION

- Executive Function (EF) plays a significant role in the control of postural activities (1, 4).
- Cognitive resources required:
  - Population characteristics (age, fall risk) (1, 3, 6, 7)
  - Individual Capacity/ reserve (Education level, fitness) (6)
  - Task Complexity (8)
ROLE OF COGNITION & MOTOR FUNCTION

• Cortical degeneration → movement impairments
• Reduced gait speed
• Gait pattern abnormalities
• Impaired postural control
• Increased fall risk (4, 10-13)

The good news: Cognitive and motor training may elicit increases in white & gray matter (14)

COGNITION STATS

• AD: 1 in 9 people 65+ (11%)
• Other causes of dementia:
  • Depression
  • B 12 deficiency
  • Normal Pressure Hydrocephalus
  • Hypothyroidism
• Diabetes: 2x increased risk

THE IMPACT

"The average Medicaid payment for a person aged 65 or older with Alzheimer's or other dementias is nine times higher than that for other beneficiaries in the same age group." —Alzheimer's Disease Facts and Figures 2010

• Using disability-adjusted life years (DALYs) Analysis: AD moved in position from the 25th most burdensome disease (1990) to the 12th (2010)

• In 2015 caregivers provided 18 billion hours of unpaid assistance to loved ones with cognitive impairment

• 77% adults with dementia require help with ADLs/ household activities vs contrast to 20% of older adults without dementia.
LET'S GET MOVING!

Transforming society by optimizing movement to improve the human experience.

"Motor performance is the result of an interaction among cognitive, perceptual, mechanical and neurologic factors."

SHUMWAY-COOK ET AL. ENVIRONMENTAL DEMANDS ASSOCIATED WITH COMMUNITY MOBILITY IN OLDER ADULTS WITH AND WITHOUT MOBILITY DISABILITIES. PTJ 2002

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CAN YOUR PATIENTS WITH COMMUNITY GOALS....
- Drive themselves to run errands
- Walk 1200 ft without assistance or supervision
- Maintain walking speed with those around them
- Carry a 7 lb. package
- Navigate 2 flights of stairs
- Navigate obstacles
- Walk on grass
- Change directions
- Reach in multiple directions
- Avoid colliding with pedestrians in a community environment

Environmental Demands Associated With Community Mobility in Older Adults Without Mobility Disabilities. Shumway-Cook et al. PTJ 2002

DEMANDS > CAPACITY → deterioration of performance is observed (17)

DUAL TASKING (DT): WHERE THE RUBBER MEETS THE ROAD
* Bottle neck theory (16)
* Limited capacity theory (15)

AGING POPULATION & DUAL TASK COSTS
* Dual task cost (DTC)
* Higher for older vs younger adults across all domains of cognitive-motor tests (17, A, 16)
* Higher for activities of cognitive processing when compared to more "automatic" secondary tasks (i.e. reciting the alphabet and reaction time)
* Higher for older adults when input & output modality match, vs. when they differ (16)
* Increased dual task cost has negative impacts on gait, balance and functional mobility (15, A, 16, 11)
Compared performance of young vs. older adults in computer-based cognitive challenge + walking activity (Go/ NoGo task)

Measured differences in:
• Reaction time “GO”
• Response inhibition (accuracy of the “NoGo”)
• Spatio-temporal gait parameters
• Event related potentials (ERPs) – voltage maps of brain activity using MoBI (Mobile Brain Machine Interface)

Malcom’s “GO/ NOGO” Study Findings

• Older Individuals demonstrated:
  • Slower response time during the “Go” task while walking
  • 4% inaccuracy rate of response inhibition in walking compared to sitting

• Younger individuals did not demonstrate a significant increase in reaction time and maintained accuracy between sitting and walking trials.
Event Related Potential (ERP) findings:

- young individuals:
  - voltage maps demonstrated large ERP shifts

- older individuals:
  - the ERP voltage area and density remained relatively unchanged

- Impairment of “cognitive flexibility”
  - Difficulty in reallocating attentional resources & adapting to the dual task condition

GO/NOGO STUDY FINDINGS: DIFFERENCES IN PRIORITIZATION

Did NOT choose “Posture First” prioritization in dual task training

- Prioritization → maximize benefit and minimize danger (17,20)
- Prioritize the “higher benefit yield” activity

In the past was generally believed that healthy adults would consistently choose a “POSTURE FIRST” strategy, however several recent studies contradict this notion. (3,6,19)

PRIORITIZATION IN DUAL TASK TRAINING
**PRIORITIZATION FRAMEWORK BY SELIGMANN, ET AL. (20)**

- Complexity of secondary task
- Age
- Expertise
- AFAR
- Prioritization
- Postural reserve

**GO/NOGO STUDY FINDINGS: DIFFERENCES IN PRIORITIZATION**

- Postural reserve?
- Low hazard estimation?
- Low complexity?

**“PD & PATHOLOGIC PRIORITIZATION”**

- Posture 2nd strategy” in individuals with Parkinson’s Disease
  - Impaired hazard estimation
  - Diminished postural “reserve”
  - Reduced ability to allocate attention to meet postural demands (34)
  - Role of basal ganglia degeneration and prioritization (20)
  - Automatic movements: goal oriented behaviors
  - This “switch” has been associated with freezing episodes in gait, particularly during dual task conditions.
  - Need for incorporating prioritization strategies and feedback into interventions
  - Patient education regarding specific strategies during dual task conditions
COGNITIVE IMPAIRMENT AND DUAL TASK COST: IMPACT ON FUNCTION

COGNITIVE IMPAIRMENT & FALL RISK
- Individuals with cognitive impairment are at 2x the risk for falls than those without (26, 27, 28).
- Severity and type of dementia have been correlated with increased fall risk in elderly.
- Strong relationships exist between dual task performance and fall risk.
- Fall likelihood increases when demands on attention increase (4, 6, 17).
- Obstacle negotiation
- Busy, complex environments
- Cognitive processing tasks while walking

THE IMPACT OF COGNITIVE DECLINE ON FUNCTION
- A study of over 4000 adults followed over 2 years found those with cognitive impairments had a much higher likelihood of mortality at the time of follow up. (22)
- Experienced difficulties with ADLS with iADLs such as managing finances and medication.
- Baseline measures of impaired cognition have been correlated with:
  - Decreased walking speed on the TUG (7, 23).
  - Difficulty negotiating up and down stairs (24).
  - Decline in dual task performance (17).
  - Reduced HR-QOL score (22, 23).
DUAL TASK ABILITY AND FALL RISK

- Dual task performance has been found to be a strong predictor of fall risk. (6,18)
  - Toulette et al. discriminated fallers vs. non fallers using DT single leg stance assessment (30)
  - Found significant gait related impairments in fallers vs. non-fallers during DT gait (not during single task gait)
- De Cock et al. multi factorial gait analysis in individuals with dementia (29)
  - Significant correlation between spatiotemporal gait deficits and level of cognitive impairment when using multi factorial gait analysis (MFGA)
  - MFGA may be a reliable predictor/ indicator of cognitive status

THE “HIDDEN COST” OF ASSISTIVE DEVICES

- Use of an assistive device correlated with increased attentional cost (30)
- Supports necessary training in appropriate use of AD

IMPACT OF TRAINING APPROACHES ON COGNITIVE MOTOR PERFORMANCE: THE EVIDENCE
THIS IS YOUR BRAIN ON EXERCISE: BRIEF LITERATURE SUMMARY

General
• Effects of acute bout of exercise on cognition in healthy adults
• Effects of exercise on cognition in individuals with dementia

Function Based
• Effects of exercise on gait and dual task performance in older adults
• Effects of exercise on balance and dual task performance in older adults
• Effects of dual task based exercise on fall risk in individuals with dementia

EFFECTS OF AN ACUTE BOUT OF EXERCISE ON COGNITION: META ANALYSIS BY CHANG ET AL

ANALYSIS
• 79 studies investigating effects of an acute exercise bout on cognition
• Healthy individuals across the lifespan

FINDINGS
• Higher intensities & longer duration of exercise (>20 minutes) highest impact on cognitive tests
• Tests of executive function and crystallized intelligence showed greatest change
• Interventions that involved aerobic and strength training superior
• Older age group showed greater change vs. young

EFFECTS OF EXERCISE ON COGNITIVE PERFORMANCE IN INDIVIDUALS WITH DEMENTIA (HESS, ET AL)

ANALYSIS
• 14 RCTs
• Participants with mild to severe dementia
• Exercises: multi component, 1 Tai Chi group
• Outcomes: Clinical Dementia Rating Scale (CDR), executive function (AMSE) & fluid intelligence

FINDINGS
• Wide range improvements across all tested parameters
• Measures of global cognition testing showed greater improvement
• Memory was least impacted by intervention
EFFECTS OF EXERCISE ON DUAL TASK WALKING ABILITY
PLUMMER ET AL (25)

ANALYSIS
- 14 RCTs studying healthy older adults
- Measured:
  - DTC of cognitive + walking activity
  - gait parameters during activity
- Interventions: multi component, majority involving a DT, 3 dance/musak based exercise groups

FINDINGS
- Increases in single and dual task gait speed
- Reduction in DTC for older individuals in experimental groups

EFFECT OF EXERCISE ON DUAL TASK PERFORMANCE AND BALANCE IN OLDER ADULTS GOBBO ET AL, 35

ANALYSIS
- 8 RCTs: impact of exercise on balance and DT ability in healthy older adults
- Interventions: 2 computer based, 1 DVD based, 6 dual task training, 1 Tai Chi
- Outcome measures: dynamic and static balance tests, dual task ability assessment

FINDINGS
- Greater improvements for interventions that included biofeedback
- The intervention with most significant effect on dynamic balance was a DVD based dual task activity performed in sitting vs. normal
- All studies demonstrated improvements in reaction time testing after exercise

DUAL TASK EXERCISE: THE EFFECT ON FALL RISK IN COGNITIVELY IMPAIRED OLDER ADULTS (BOOTH ET AL, 34)

ANALYSIS
- 8 RCTs
  - All interventions were provided in a group setting
  - Multi component, Tai Chi, music based activities
  - Study outcomes measures:
    - Self report of fall history
    - Clinical balance measures (ie. TUG, BBS)
    - Postural sway
    - Gait parameters/speed

FINDINGS
- DT exercise had the greatest effect on gait speed
- 4 studies demonstrated significant reduction in fall frequency
- Improved performance on TUG & BBS scores
- Greatest effect size for individuals with mild cognitive impairment vs. moderate severe
Pedroso and colleagues compared individuals with AD participating in dual task training vs. control (no intervention).

- Dual task group performed walking, ball bouncing or weight training with semantic exercises, as well as reacting (start/stop or change exercise in response to music change).
- Intervention occurred 3x per week, 60 minutes over 4 months.

- Improvements in BBS, reduction in reported falls, improved cognitive function (clock drawing test and Frontal Assessment Battery).

**RECOMMENDATIONS FOR MAXIMIZING DUAL TASK ABILITY AND FUNCTION IN OLDER INDIVIDUALS**

- Multi component interventions are better than isolated approaches.
- Adding an aerobic component may yield a greater effect.
- Biofeedback is helpful to improve dual task ability.
- Group exercise is effective (Tai Chi or music therapy).
- Interactive technology systems with cognitive challenges.
- Prioritization training should be incorporated.
- Interventions should factor personal characteristics such as affect, postural & cognitive reserve, saliency of activity, self efficacy, and co-morbidities to maximize training effects.

**GOBBO’S CHALLENGE**

- “It is unclear whether the exercises chosen for older adults are appropriate, acceptable, or intense enough to elicit an effect great enough to impact static/dynamic balance in dual task conditions.” - Gobbo et al. 2013 (35)
NOVEL INTERVENTIONS & DUAL TASK TRAINING

• Gregory et al. RCT investigated the effects of intervention on gait parameters and cardiovascular health (36)
• Group based Aerobics + Square Stepping Exercise + Dual task training
• Outcomes: Gait speed, step length and stride time variability
• Findings:
  * Significant improvements across all parameters in walking DT conditions compared to control
  * Improvements were maintained at 6 month follow up
NOVEL INTERVENTION: EXERGAMING

Anderson et al compared interactive cyber cycling to traditional cycling (37)

• Measured cognitive performance, clinical status of mild cognitive impairment (MCI), fitness levels, and plasma BDNF levels
• Significant results: cyber cycling group compared to traditional exercise
  • Improved performance on cognitive testing
  • Calculated 23% relative risk reduction for MCI
  • Significant differences in plasma BDNF levels; ⇒ increased neural plasticity?

• ACE Pilot RCT: compared 2 cyber cycling groups with different cognitive demands
  • Those with higher cognitive demands (gaming) demonstrated significant improvements in both cognitive tests and ecological validity measures (38)

DUAL TASK POWER TRAINING IN OLDER INDIVIDUALS AND EFFECT ON FALLS (39)

Daly et al cited the need for training functional power strategies + dual task training in geriatric population

• Functional relevance, reduced fall risk
• Randomized older people at risk for falls into usual care or Dual Task Functional Power Training (DTFPT) group
• Phases of intervention: 6 months supervised, 6 months step down, 6 month follow up
• Primary measure: Reduction in number of falls
• Secondary:
  • Functional muscle strength and power
  • Isolated lower limb muscle strength
  • Fall-related self efficacy
  • Quality of life (HR-QOL)

Findings: ??? TBD

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PROCEDURAL MEMORY BASED ADL TRAINING

- Activities such as grooming, sending postcard, paying a check, preparing a sandwich, counting money, using a phone, etc. were trained and assessed for time improvements.
- Therapists delivered 15 sessions training specific tasks, providing verbal support, cues, and answers to questions.
- Despite lack of improvement on neuropsychological testing, the individuals with AD performed significantly better in the trained as well as untrained ADL tasks compared to timed controls.

The Benefits of Cooking with Alzheimer’s: A Caregiver’s Guide


EVIDENCE BASED EXAMPLES FOR DT TRAINING

- Card “treasure hunt”
- Layer cognitive components (addition, colors, suit instructions)
Translating evidence into practice

CHALLENGES AND RECOMMENDATIONS

- Standardization of methods lacking
- Secondary task difficulty: Challenging enough to load attention but not so difficult that it produces anxiety
- Assess single task performance before adding other
- Consistent consistency of challenges over time
- Choose a "whole task approach": training cognitive and motor tasks simultaneously yields better results (Kramer, 1996)
- fMRI studies revealed increased neural efficiency after "whole task" dual task training (Erickson et al, 2007)

DUAL TASK OUTCOME MEASURES

- TUG with Cognitive Task or Dual motor task
  - Backward by 3’s alternate letters
  - Difference between TUG and TUG-COG in healthy elderly = 8.4 s and 9.7 s
  - 8.2 s difference for patients with PD

- Stops Walking When Talking
  - STOP = + (low sensitivity)
DUAL TASK OUTCOME MEASURES

- Walking While Talking Test (Walking while reciting alternate alphabet letters)
  - Calculate time to ambulate 40 ft while performing.
  - 1) WWT-simple: walking while reciting the alphabet aloud
  - 2) WWT-complex: walking while reciting alternate letters of the alphabet aloud (or counting backward by 3s)
- Cut-offs:
  - >20 s for community dwelling adults and fall risk
  - >33 s dementia/AD
  - Speed <70 cm/ s reliable indicator of frailty

OUTCOME MEASURES FOR DUAL TASK ABILITY

Walk and Remember Test (WART)

- Protocol:
  1) Single task walking
  2) Single task forward digit span testing
  3) Dual-task walking while remembering a digit span
- Narrow path/BOF option
- Calculate dual task cost: (Dual task - Single task)/ single task
- Count steps “off the path”

FRAMEWORK FOR INTERVENTIONS

- Cognitive–Didactic Approach: focuses on the cognitive impairment.
  - Patient education
  - Acceptance exercises (if possible)
  - Challenged sequentially: be tasked and asked to self reflect on performance and problems solve new strategies (Vanderploeg, et al. 2006)

- Functional Experiential Approach (Task Oriented Approach): patients treated in group settings working on natural environments (games, outdoor activities, exercise, cooking, current events, job related activities)
  - Overall recommendation: use them in a complementary way, consider diagnosis and stage
FRAMEWORK FOR INTERVENTIONS

- Manipulating Patient Task or Environment
  - Open vs. closed environments (increase auditory and visual stimulation)
  - Implicit vs explicit memory
  - Incorporate more "ballistic" or dynamic activities (working backward, cue into automaticity for LESS cognitive demand)
- Changing surroundings and sensory input while adding cognitive task
- Increase environmental obstacles

INTERVENTIONS: TRANSLATION TO CLINICAL PRACTICE

- Pneumonic for memorization combined with movement
- Name to face games - memory/recognition
- 20 questions problem solving
- Video games - Attention and perception; challenges with task variability, feedback, requires adaptation and provides motivation
- Speed of processing: Gaze Stability tests, Dynavision
- Testing task shifting
- Multi step functional tasks (SALIENCY)

Auditory discrimination: identify voices or noise
- Visual discrimination: identify types of fruits, state names, items in the grocery store, etc.
- Visual Spatial Tasks: Patients were shown pictures before and after balance tasks and asked to memorize pictures and respond if the picture was the same as the one performed prior to the task
- Visual Imagery spatial tests: Patients asked to imagine and tell clinician topographical routing information
- N Back Task: Patients asked to repeat numbers, days or months backward
- Tell the opposite: Patients were asked to name the opposite direction of their own actions

Adapted from: Weightman, Margaret M. PhD, PT and McCulloch, Karen, PT, PhD, NCS. Dual Task Assessment and Intervention. Chapter 8 of Mild TBI Rehabilitation ToolKit.
REFLECTIONS

- What ideas do you have?
- What have you seen work in your practice?
- What has NOT worked? Why?
- What new or different strategy could you implement with your current patients?

PUTTING IT ALL TOGETHER… SUGGESTIONS FOR CLINICAL PRACTICE

- Perform or consult with others performing cognitive assessments
- Ask questions and LISTEN to your patients.
- Involve family members
- Perform basic cognitive screening
- Use Cog, MoCa, detailed history
- Make DTT activities functional and challenging!
- Encourage engagement/social interaction during treatment with other patients
- Use of peer mentors for patients with potential cognitive deficits is helpful to return to recovery situations
REFERENCES


REFERENCES


• 34. Booth et al. Interventions incorporating physical and cognitive elements to reduce falls in cognitively impaired older adults: a systematic review. JBI Database of Systematic Reviews and Implementation Report 2016.


• 42. Martha R. Crowther, PhD, MPH,1 Michael W. Parker, DSW,2 W. A. Achenbaum, PhD,3 Walter L. Larimore, MD,4 and Harold G. Koenig, MD. Rowe and Kahn's Model of Successful Aging Revisited: Positive Spirituality— The Forgotten Factor. The Gerontologist Copyright 2002 by The Gerontological Society of America Vol. 42, No. 5, 613–620

• 43. Renata Valle Pedroso a,*, Fla´ via Gomes de Melo Coelho a, Ruth Ferreira Santos-Galduro´ z a,b,Jose´ Luiz Riani Costa a, Sebastia˜ noGobbi a, Florindo Stella a,c. Balance, executive functions and falls in elderly with Alzheimer’s disease (AD): A longitudinal study. Balance, executive functions and falls in elderly with Alzheimer’s disease (AD): A longitudinal study


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