Movement Strategy Training in Parkinson’s Disease for Gait and Transfer Difficulties

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Outlines

• Gait impairment
• Freezing of gait
• Treadmill training
• Nordic walking
• Brisk walking
• Cued training
• Strategies to enhance transfer tasks
Locomotion

Rhythmic
Repetitive
Automatic
Least attention
Modify steps
Gait difficulty - most disabling cardinal sign of Parkinson's disease

<table>
<thead>
<tr>
<th>On medication phase</th>
<th>PD</th>
<th>Healthy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Velocity m/s</td>
<td>0.7-1.0</td>
<td>1.1-1.4</td>
</tr>
<tr>
<td>Stride length m</td>
<td>0.9-1.1</td>
<td>1.2-1.5</td>
</tr>
<tr>
<td>Cadence step/min</td>
<td>93-104</td>
<td>106-112</td>
</tr>
</tbody>
</table>

**Gait is more affected when ↑ task complexity or cognitive demand:**

- turning, sudden stop, obstacle, changing speed
- ↓ gait speed & stride length
- ↓ symmetry and inter-limb coordination
- ↑ stride to stride variability

*Figure 1: Increased stride-to-stride variability in the stride interval time series of a PD patient (below) compared to a healthy control (above).*

Giladi et al. 2002

Freezing of gait

• An episodic inability to generate effective stepping, usually lasting for a few seconds
• Usually occurs during off-medications and during gait initiation, turning, going through narrow doorways, and dual-tasking - ↑ fall risks
Freezing of gait

Cognitive domains most affected in people with PD who freeze

Executive Function
- Updating
- Shifting
- Inhibition

Attention
- Switching
- Divided
- Sustained
- Selective

Executive Control
- Selective
- Switching
- Divided

Inhibition

Posner and Petersen, 1990 (Attention)
- Executive control
- Alerting
- Orienting

Miyake et al, 2000 (Executive Function)

McDowd, 2007 (Attention)

Physical activity level is reduced at **EARLY** stage PD

<table>
<thead>
<tr>
<th></th>
<th>Healthy</th>
<th>PD (HY I)</th>
<th>PD (HY II)</th>
<th>PD HY (III)</th>
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<tbody>
<tr>
<td>Total number of daily step</td>
<td>7816</td>
<td>6302*</td>
<td>5335*</td>
<td>4840*</td>
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<td>Time spent walking (s)</td>
<td></td>
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<tr>
<td>30s-2min</td>
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<td>1463</td>
<td>1483*</td>
<td>1822*</td>
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<td>&gt;2min</td>
<td>2386</td>
<td>1337</td>
<td>1340*</td>
<td>936*</td>
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<td>Frequency of walking bouts</td>
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<tr>
<td>30s-2min</td>
<td>38</td>
<td>37</td>
<td>28*</td>
<td>29*</td>
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<tr>
<td>&gt;2min</td>
<td>8</td>
<td>5*</td>
<td>5*</td>
<td>3*</td>
</tr>
</tbody>
</table>

* significantly less than healthy subjects

**Reduced aerobic capacity**

- Shorter distance covered during 6-minute walk test
- ↓ VO2 max in mild to moderate PD

Garber and Friedman (2003), Lord et al. J Neurol (2013)
Gait difficulty is a clinical red flag that marks emerging disabilities and poor QoL

Shulman L. Understanding Disability in PD. Movement Disorders 2010;25:S131-135
What do patients really want to receive for their treatment?

Of the 10 domain of function, patients have rated in order of importance

- **Walking**
- Slowness
- ADL
- Fatigue
- Stiffness
- Sleep
- Thinking
- Tremor
- Emotional distress
- Pain

Nisenzon AN Parkin Relat Disord (2011)
Gait disorders

↑ Gait ability
↑ Dual-task gait performance
↓ Freezing of gait
↓ PD progression

↑ Aerobic capacity
Physiotherapy in Parkinson’s Disease: A Meta-Analysis of Present Treatment Modalities

Danique L. M. Radder, MD1,*, Ana Lígia Silva de Lima, PhD1,*, Josefa Domingos, MSc1,2, Samyra H. J. Keus, PhD1,3, Marlies van Nimwegen, PhD1, Bastiaan R. Bloem, MD, PhD1, and Nienke M. de Vries, PhD1

• Treadmill training, strategy training improved gait
• Nordic walking improved motor symptoms, balance, and gait.
Treadmill gait training
Nordic walking
Brisk walking
Cued training
Treadmill training (TT)

• A task-specific, repetitive walking practice with treadmill
• Treadmill training with harness support allow people with PD to walk safely in an upright position, gradually increase walking speed and step length.
Effects of Treadmill training (TT)

After 4-8 weeks of training positive effects:

- UPDRS motor score
- walking speed
- stride length
- walking endurance


Effects of treadmill training could be maintained for 3-6 months after treatment completion (Bello et al. 2013, Miyai et al. 2002, Picelli et al. 2013).
Treadmill training (TT) – Aerobic capacity

- TT working on a higher aerobic intensity (70-80% HRR), not low intensity (HRR 40-50%) improved walking economy and VO2 max (Shulman et al. 2013)

JAMA Neurology | Original Investigation

Effect of High-Intensity Treadmill Exercise on Motor Symptoms in Patients With De Novo Parkinson Disease
A Phase 2 Randomized Clinical Trial

Margaret Schenkman, PhD, PT; Charity G. Moore, PhD; Wendy M. Kohrt, PhD; Deborah A. Hall, MD, PhD; Anthony Delitto, PhD, PT; Cynthia L. Comella, MD; Deborah A. Josbeno, PT, PhD; Cory L. Christiansen, PhD, PT; Brian D. Berman, MD, MS; Benzi M. Kluger, MD; Edward L. Melanson, PhD; Samay Jain, MD; Julie A. Robichaud, BS-PT, MHS, PhD; Cynthia Poon, PhD; Daniel M. Corcos, PhD

- Six-month high intensity aerobic TT training (80%-85% max. HR) attenuated PD motor symptoms in de-novo, non-medicated PD (UPDRS 0.3 vs 3.2)
Nordic walking

• A full-body aerobic walking activity with moderate-intensity, using poles with specially designed rubber boots and wrist strap.

• Alternate large arm swing with coordinated stepping

(Herfurth et al. 2015, Zanardi et al. 2019)
Effects of Nordic walking

After 12 weeks of supervised NW training at 60-80% Heart rate reserve (HRR)
• walking endurance
• walking speed
• functional mobility
• balance performance (Cugusi et al. 2015)

After 6-month supervised NW training:
• motor symptoms (UPDRS motor score)
• stride length
• Balance performance (Reuter et al. 2011)
Brisk walking (BW)

- A moderate-intensity aerobic training
- Focus on walking at a fast speed, with long steps and large arm swing (Tully et al. 2005)
- No equipment is needed
Six-month community-based brisk walking and balance exercise alleviates motor symptoms and promotes functions in people with Parkinson's disease: A randomized controlled trial (Mak and Wong-Yu JPD 2021)

**Week 1-6**
- PT supervised once weekly to learn BW techniques
- Reached weekly 150 min mod. intensity ex. at the end of week 6

**Week 7-26**
- PT supervised sessions tapered to once monthly
- Participants continued BW ex. 2-3 times weekly, monitored by smart watch

**Assessment**
- Post 6-week training, Post 6-month training
- Gait, balance, PD motor symptoms

HRR: 40-60%
Effects of Brisk walking training

Pre BW training    Post BW training
## Effects of Brisk walking training

<table>
<thead>
<tr>
<th></th>
<th>$\text{Post}_{6\text{wk}}$-$\text{Pre}$</th>
<th>$\text{Post}_{6\text{m}}$-$\text{Pre}$</th>
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<tbody>
<tr>
<td></td>
<td>BW</td>
<td>CON</td>
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<tr>
<td>MDS-UPDRS motor score (0-132)</td>
<td>-5.5±4.6</td>
<td>-1.6±3.4</td>
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<tr>
<td>6MWD (m)</td>
<td>47.7±42.3</td>
<td>5.4±58.7</td>
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<tr>
<td>Mini-BEST score (0-28)</td>
<td>2.4±2.3</td>
<td>-0.3±2.0</td>
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<tr>
<td>FGS (cm/s)</td>
<td>11.9±19.2</td>
<td>1.9±19.1</td>
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<tr>
<td>TUG time (s)</td>
<td>-1.1±1.5</td>
<td>-0.2±1.3</td>
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</tbody>
</table>

*p<0.05

(Mak and Wong-Yu JPD 2021)
Dual-task training, outdoor training

- Improve automaticity – balance, gait ability
- Improve cognitive functions – initiation, set-shifting ability, attention switching, task monitoring, inhibition of inappropriate actions

Cognitive tasks
- counting backwards
- generating category lists (fruit, sports)

Motor tasks
- carrying a plate with a glass on top
- transfer objects between hands
Improved dual-task mobility and balance post-training and at 12-month follow-up

Wong-Yu and Mak
Parkin Rel Disord (2015)
Addition of a non-immersive virtual reality component to treadmill training to reduce fall risk in older adults (V-TIME): a randomised controlled trial


Participants with fall history
6 weeks of training
• Feet position during walking projects on the screen
• Real-life challenges: obstacle, multiple pathways, distractors, dual-tasking, response selection

At 6-month follow-up
• ↑ endurance, obstacle clearance, and mobility
• ↓ fall rate by 55% in PD patients
Dual-task approach: Do or don’t?

- Those with advanced level of disease severity
- Frequent fallers
- Severe freezing of gait
- Cognitive impairment
- Avoid dual task, but focus on their movement/function using attention
Cue training for gait

- External cues include visual, somatosensory and rhythmic auditory cues (Fietzek et al. 2014; Nieuwboer et al. 2007)

Stride length

<table>
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<tr>
<th>Group by Cue Type</th>
<th>Study name</th>
<th>Hedges’s g and 95% CI</th>
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<tr>
<td>auditory</td>
<td>Baker et al. 2007</td>
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<td>del Orma &amp; Cudermo, 2004</td>
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<td>Nieuwenboer et al. 2007b</td>
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<td>Overall</td>
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Gait velocity

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</table>
Cue training for gait

• A recent review and meta-analysis study (Radder et al. 2020)
• 2-8 weeks of strategy training (including cueing)
• Improved balance and gait outcomes
• Minimal carry-over effects
Cueing for Freezing of gait

• Cueing can facilitate gait initiation/continuation by helping freezers to focus back to walking when FOG occurs (Morris et al. 2010)
• Auditory cues was found to be more effective than visual cues (Zhao et al. 2016)
• 2-3 week of cue training could reduce perceived FOG severity (Fietzek et al. 2014, Nieuwboer et al. 2007) but a recent meta-analysis indicated cue training has no effect on reducing FOGQ score (Radder et al. 2020)
Novel cueing devices

Barthel et al. (2018)
Janssen et al. (2017)
Griffin et al. (2011)
Novel cueing devices

Barthel et al. (2018)

Janssen et al. (2017)

Griffin et al. (2011)

Tao and Mak  Easypacer™
Cognitive training for freezing of gait in Parkinson’s disease: a randomized controlled trial

Courtney C. Walton1, Loren Mowszowski1,2, Moran Gilat1, Julie M. Hall1,2, Claire O’Callaghan1,4, Alana J. Muller5, Matthew Georgiades1, Jennifer Y. Y. Szeto1, Kaylena A. Elgoetz Martens1, James M. Shine1,2, Sharon L. Naismith1,2 and Simon J. G. Lewis1

7-week of cognitive training to target executive function

Reduced time of freezing at ON medication
Reduced information processing time

Table 2: Primary outcome data between groups before and after intervention

<table>
<thead>
<tr>
<th></th>
<th>AC group</th>
<th>CT group</th>
<th>Comparison of change</th>
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<tr>
<td>%TF on#</td>
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<tr>
<td>BL</td>
<td>6.61 (3.92, 11.15)</td>
<td>9.16 (5.52, 15.19)</td>
<td>0.3 (0.14, 0.62); T = -3.36; p = 0.002; d = 1.02</td>
</tr>
<tr>
<td>FU</td>
<td>11.99 (7.11, 20.23)</td>
<td>4.95 (2.99, 8.21)</td>
<td></td>
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<tr>
<td>Change from BL</td>
<td>1.81 (1.08, 3.05)</td>
<td>0.54 (0.32, 0.90)</td>
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<tr>
<td>%TF off#</td>
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<tr>
<td>BL</td>
<td>16.61 (9.22, 29.93)</td>
<td>8.02 (4.59, 13.98)</td>
<td>1.07 (0.64, 1.76); T = 0.26; p = 0.800; d = 0.06</td>
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<tr>
<td>FU</td>
<td>15.44 (8.57, 27.81)</td>
<td>7.94 (4.55, 13.85)</td>
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<tr>
<td>Change from BL</td>
<td>0.93 (0.64, 1.34)</td>
<td>0.99 (0.70, 1.40)</td>
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</tbody>
</table>

#Analysis conducted on Log10 transformed data and represented by geometric means. The change from baseline is a ratio of the geometric means at follow-up compared with baseline. The comparison of the changes from baseline is the ratio of the change from baseline for the CT group compared the AC group. 95% CIs are presented in brackets. Direction of change and statistical significance was matched in the FAS analysis.
## Summary on the benefits of gait training

<table>
<thead>
<tr>
<th></th>
<th>UPDRS or MDS-UPDRS motor score</th>
<th>Balance</th>
<th>Gait speed</th>
<th>Stride length</th>
<th>Functions (e.g. TUG, STS)</th>
<th>Dual-task walking</th>
<th>Aerobic capacity</th>
<th>↓ FoG</th>
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<tbody>
<tr>
<td>Brisk walking</td>
<td>🔄</td>
<td>✔️</td>
<td>✔️</td>
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<tr>
<td>Nordic walking</td>
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<td>✔️</td>
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<td>Dual-walking</td>
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<tr>
<td>Gait training with cues</td>
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<td>✔️</td>
<td>✔️</td>
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<td>+/-</td>
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</tbody>
</table>
Transfer difficulties

Part-to-whole practice

Cognitive movement strategy
PD patients were found to have marked difficulties to perform functional tasks which consist of movement subcomponents.

- Problems to **LINK UP** movement components

**Difficulties in transfer activities**

- Rolling
- Lying to sitting
- Sit-to-stand
Switching of Movement Direction Is Central to Parkinsonian Bradykinesia in Sit-to-Stand

Margaret K.Y. Mak, PhD, and Christina W.Y. Hui-Chan, PhD

<table>
<thead>
<tr>
<th></th>
<th>Control subjects (n = 20)</th>
<th>Patients with PD (n = 20)</th>
<th>Control subjects simulating PD slow speed (n = 15)</th>
<th>Patients vs. controls at natural speed (P)</th>
<th>Patients vs. controls at simulated slow speed (P)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Peak horizontal and vertical velocities of the body centre of mass (m/sec)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Peak horizontal velocity</td>
<td>0.43 ± 0.07</td>
<td>0.33 ± 0.08</td>
<td>0.31 ± 0.07</td>
<td>0.000&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.474</td>
</tr>
<tr>
<td>Peak vertical velocity</td>
<td>0.60 ± 0.11</td>
<td>0.37 ± 0.11</td>
<td>0.37 ± 0.11</td>
<td>0.000&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.563</td>
</tr>
<tr>
<td><strong>Time taken to complete STS (sec)</strong></td>
<td></td>
<td></td>
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<tr>
<td>Total time</td>
<td>1.91 ± 0.28</td>
<td>2.86 ± 0.77</td>
<td>2.94 ± 0.76</td>
<td>0.000&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.768</td>
</tr>
<tr>
<td>T&lt;sub&gt;1&lt;/sub&gt;</td>
<td>0.62 ± 0.15</td>
<td>1.00 ± 0.31</td>
<td>1.00 ± 0.31</td>
<td>0.000&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.979</td>
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<tr>
<td>T&lt;sub&gt;2&lt;/sub&gt;</td>
<td>0.11 ± 0.04</td>
<td>0.24 ± 0.14</td>
<td>0.17 ± 0.06</td>
<td>0.000&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.050&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Seat-off</strong></td>
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<tr>
<td>T&lt;sub&gt;3&lt;/sub&gt;</td>
<td>0.22 ± 0.10</td>
<td>0.35 ± 0.16</td>
<td>0.46 ± 0.17</td>
<td>0.006&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.064</td>
</tr>
<tr>
<td>T&lt;sub&gt;4&lt;/sub&gt;</td>
<td>0.95 ± 0.25</td>
<td>1.27 ± 0.40</td>
<td>1.31 ± 0.44</td>
<td>0.004&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.769</td>
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Research Articles

Cued Task-Specific Training is Better Than Exercise in Improving Sit-to-Stand in Patients with Parkinson’s Disease: A Randomized Controlled Trial

Margaret K.Y. Mak, PhD and Christina W.Y. Hui-Chan, PhD*
**Speed of STS**

Within-group

** P <0.01
*** P <0.001

- AV Group
- Ex Group
- Control Group
Cognitive movement strategy

• Break down a complex motor task into small component parts
• Consciously plan and rehearse each movement component before execution
• Practice each component task before transferring to whole task

Rolling to the left

Bring the legs to the L side
Turn the trunk
Bring the R arm across

(Morris 2000, Keus et al. 2007)
Transfer activities using cognitive movement strategy

(Morris 2000, Keus et al. 2007)
Conclusion

Early - Brisk walking, Nordic walking, High intensity Treadmill training, Dual task walking

↑ Gait ability
↑ Dual-task gait performance
↑ Gait ability
↓ PD progression
↓ Freezing of gait

Gait disorders

Sustained training Community-based

Moderate
• Brisk walking
• Nordic walking
• Treadmill training
• Cueing
• Cognitive movement strategy for transfer tasks

↑ Aerobic capacity
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