Effects of exercise on cognition in Parkinson’s disease: The link between executive functions and gait

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**PURPOSE**

To investigate the effects of aerobic and goal-based exercise interventions on executive functions (EF) and gait in Parkinson’s disease.

**HYPOTHESIS**

[1] Aerobic exercise will improve both EF and gait, while goal-based exercise will improve primarily gait. [2] Improvements in EF will be associated with improvements in gait.

**KEY FINDINGS**

Both EF and step time variability (during dual task) improved after aerobic exercise, whereas only step time variability (during single task) improved after goal-based exercise.

**Background**

- In Parkinson’s disease (PD), both executive functions and gait are impaired. Given that deficits in EF have been associated with gait impairments, it has been suggested that individuals with PD may rely on cognition to control gait. However, it remains unknown whether improvements in executive functions could contribute to better gait control in individuals with PD.
- Due to its multifactorial underlying mechanisms, the treatment of cognitive deficits in PD is a challenge and may demand the use of multiple approaches.
- A recent review suggested that aerobic exercise has been associated with improvements in physical exercise to cognition in PD 1,4.
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- A recent review suggested that aerobic exercise has been associated with improvements in physical exercise to cognition in PD 1,4.
- Executive functions assessment: working memory (Digit Span), set-shifting (Trail Making Test), and inhibition (Stop Test).
- **Goal assessment**: 3-single and 3-dual task walking trials were performed on a Zeno Walkway System. Step length, step time, step width and their respective coefficient of variation (CV), as well as gait speed and percentage of time spent in double support were calculated using PKMAS software.

**Methods**

- **Participants** were randomly assigned into two exercise groups and attended three 1-hour sessions per week for 12 weeks.
- **Aerobic exercise**: 40 minutes on a cycle ergometer; intensity levels started at 40-50% heart rate reserve (HRR) and increased to 60-70% HRR by week 4.
- **Goal-based exercise**: 60 minutes of walking exercises coordinating upper and lower limbs, non-progressive muscle-tensing exercises using resistance bands and body weight, and whole body stretching exercises (standardized protocol: PD SAFeX™, without eyes closed).
- **Executive functions assessment**: working memory (Digit Span), set-shifting (Trail Making Test), and inhibition (Stop Test).
- **Goal assessment**: 3-single and 3-dual task walking trials were performed on a Zeno Walkway System. Step length, step time, step width and their respective coefficient of variation (CV), as well as gait speed and percentage of time spent in double support were calculated using PKMAS software.

**Results**

- **All participants performed the Trail’s part A faster after exercise** (<p>0.009).
- **A group by time interaction for the Stroop (interference condition) approached significance** (<p>0.056), revealing that only the aerobic group improved at post-test (Fig 1).
- **All participants decreased step time, increased cadence and step width after exercise, only in the dual-task condition** (<p>0.05).
- **A group by time by walking task interaction for step time variability** reached significance (<p>0.058), showing that, while goal-based exercise decreased variability in the single task, aerobic exercise decreased variability in the dual-task condition at post-test (Fig 2).
- **Changes in Digit Span forward were associated with reduced step time variability** (aerobic: <i>r</i> = 0.41; goal-based: <i>r</i> = 0.48) (Fig 3) and double support variability (aerobic: <i>r</i> = 0.50) during dual-task.

**Discussion**

- Although participants from both groups improved processing speed after exercise (faster Trail’s A), improvements in EF were only found after aerobic exercise. These findings suggest that the aerobic component of exercise may be critical to improve EF in PD.
- Notably, aerobic exercise also improved step time variability during dual task but not single task, whereas goal-based exercise improved step time variability during single task but not dual task. Thus, it seems that aerobic exercise did not improve gait directly (single task), but rather improved individuals’ ability to handle multiple tasks. Since studies have shown that step time variability is a gait parameter sensitive to cognitive load during walking [2], these results suggest that aerobic exercise improved cognition which led to better gait control during taxing situations.
- Given that pure gait improvements (single task) were not found after aerobic exercise, it was not surprising that Stroop Test results and step time variability were unrelated.
- On the other hand, with independent correlations between Digit Span and gait for each group, changes in Digit Span were associated with changes in gait variability during dual task. This would suggest that as walking memory improves so does gait variability (and vice versa). This leads to the conclusion that working memory and gait variability may be always highly related.
- This is the first study to demonstrate that exercise-related changes in EF may influence gait in PD, and importantly, this may be the result of the improved ability to handle multiple tasks rather than gait directly. The current findings suggest that aerobic exercise may be an effective complementary strategy to treat cognitive deficits in PD.
- Future research should evaluate the effect of exercise on different cognitive domains and compare these effects in individuals with PD with and without cognitive impairment.

**Table 1. Participant’s demographics and clinical information**

<table>
<thead>
<tr>
<th>Group</th>
<th>Age (year)</th>
<th>UPDRS-III</th>
<th>MoCA</th>
<th>Years of Education</th>
<th>GDS</th>
</tr>
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<tbody>
<tr>
<td>Aerobic (n=23)</td>
<td>70.9 (15)</td>
<td>25.93 (8.18)</td>
<td>25.04 (4.65)</td>
<td>14.30 (5.26)</td>
<td>6.91 (6.58)</td>
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<tr>
<td>Goal-based (n=25)</td>
<td>68.6 (8.73)</td>
<td>26.32 (9.94)</td>
<td>25.00 (3.86)</td>
<td>14.24 (3.17)</td>
<td>9.52 (7.62)</td>
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</tbody>
</table>

**Key References**


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