CAN DANCE IMPROVE TURNING IN PEOPLE WITH PARKINSON’S DISEASE?

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ABSTRACT

Objective: This study primarily investigates the effects of a dance intervention on selected functional parameters during the 180° turning phase of the Timed Up & Go (TUG) test in people with Parkinson’s disease (PwP). Individual biomechanical changes in the affected shoulder and pelvic girdle dissociation are also described.

Methods: Fifteen adults clinically diagnosed with idiopathic Parkinson’s Disease were allocated into dance intervention (DIG; n=7; age 73±2 years) and control (CG; n=8; age 64±5 years) groups. Prior to intervention, all participants completed the Unified Parkinson’s Disease Rating Scale–part III, the International Physical Activity Questionnaire-short form, and the Hoehn & Yahr scale. Pre- and post-intervention, while wearing the Xsens® full-body 3D motion suit, all participants performed the TUG test twice (at a comfortable walking speed, and as quickly and safely as they could). The dance intervention lasted for three months (one hour, twice a week). Results: At participant’s comfortable walking speed, the functionality during the 180° turning remained unaffected following the dance intervention. However, at participant’s fast speed, the DIG significantly reduced the number of steps with a large effect size (p=0.01; d=2.26; CI= 0.367; 5.19), and the total time taken to complete the 180° turning with a medium effect size (p=0.22; d=0.65; CI=-0.759; 1.9). Post-intervention, most participants in the DIG reduced girdle dissociation, turning more “en bloc”.

Conclusion: Dance can improve selected functional parameters during the 180° turning phase of the TUG at fast speed in PwP. The current results should be considered in rehabilitation programs involving PwP.

Key-words: Dance. Parkinson’s Disease. Functional mobility. Turning.
INTRODUCTION

Parkinson’s disease (PD) is the fastest growing neurodegenerative disorder affecting more than nine million people worldwide [1, 2]. It is characterized by a variable combination of motor and non-motor symptoms that jointly affect quality of life and everyday functioning of people with PD (PwP) [3]. PD causes a severe impairment in the functional autonomy of people with PD (PwP), leading to walking and turning gait difficulties that contribute to falls and to fall-related injuries with a subsequent negative impact in the quality of life [4].

Turning embedded in locomotion is essential for functional mobility and has a common occurrence in daily activities; in fact, the majority of activities require 3-4 turns, and over 50% of daily steps are turning steps [5]. Turning performance in PwP is normally compromised and considered a challenging component of locomotive ability, which can lead to significant disability, falls and loss of function [6, 7]. In addition, PwP tend to take shorter turns with smaller turn angles and more steps than healthy individuals [8]. In general, PwP “turn en bloc”, demonstrating a loss of axial rotation of the spine, with little dissociation between head, trunk and lower limbs whilst turning [9, 10].

The traditional treatment of PD is through pharmacological drugs that ease, but cannot reduce, all clinical symptoms. However, given the multifaceted nature of PD, there is a growing awareness that delivery of integrated and personalized care with a multidisciplinary approach better serve the needs of PwP [11]. Available data indicate that complementary therapies, such as dancing, alongside drug therapy increase physical function, functional mobility and quality of life in PwP [12, 13]. Several systematic reviews with meta-analyses on the effects of dance classes in PwP have shown that dance can be feasible, safe and enjoyable than other non-pharmacological treatments [14, 15, 16, 17]. These reviews have also verified that dance can improve –inter alia– the functional mobility, balance, motor impairments severity, walking gait, freezing, depression and quality of life in PwP.

Although dance is an activity as old as the human race [18] and has been shown to improve elements of health [19], relatively few studies have biomechanically analysed its effects in relation to PwP. For instance, Solla et al [20] showed that a 12-week program of Sardinian folk dance significantly improved walking gait speed and
stride length in PwP, while Delabary et al [21] suggested that a 12-week program of Brazilian dance can lead to improvements in selected spatiotemporal parameters of walking gait in PwP. Hulbert et al [22] also found individual biomechanical changes on arm velocity, trunk rotation and gait (speed and step length) in PwP during and following dance, showing that the amount and direction of change was different for each participant, and demonstrating the unique person-centred effects of dance in PD. Even so, the effects of dance on specific adjustments on inter-girdle movement during functional tasks in PwP are still unknown.

To the best of our knowledge, only one study has investigated the effects of a dance intervention on turning ability using biomechanical parameters associated with a successful turn [23]. These authors pointed out that those who participated in the dance intervention turned more ‘en bloc’ compared to controls, and as a result they were better able to coordinate head and trunk with the limbs.

Therefore, the main aim of the current non-randomised controlled trial was to investigate the effects of a dance intervention on the number of steps (NS) and the time taken to complete the 180° turning phase (TTP) during the Timed Up & Go (TUG) test in PwP. A secondary aim was to describe individual changes in the affected shoulder and pelvic girdle dissociation.

METHODS

Participants
The participants were 15 adults aged between 50 and 80 years, with a clinical diagnosis of idiopathic PD, staging between 1 and 4 of the Hoehn & Yahr Scale. In total, 40 volunteers were recruited from Dance for Parkinson’s Projects, West-Midlands County, UK, and from Parkinson’s UK. Twenty-five were not included either because they did not meet the inclusion criteria or they were unavailable. The sample selection process is illustrated in the flowchart presented in Figure 1.

Inclusion criteria involved: confirmed diagnosis of PD according to the London Brain Bank Criteria [24], able to understand the verbal instructions for the tests and to walk, or attempt to walk independently with no walking aid. Exclusion criteria included: recent surgeries, deep brain stimulation (DBS); severe heart diseases, uncontrolled
hypertension, myocardial infarction within a period of less than one year, fitted with a pacemaker, prostheses in the lower limbs, stroke or other associated neurological diseases.

The participants were allocated into two groups: dance intervention (DIG, n= 7) and control (CG, n=8) groups. The DIG participated in an on-going Dance for Parkinson’s Group in West Midlands, England, for 3 months carrying out two 1-hour sessions a week (1 instructor-led session and 1 home session following a specially prepared video). The CG did not alter their personal lifestyle and carried out moderate physical activity over the same 3-month period.

All participants gave their informed consent before starting the data collection and the research was approved by University of Wolverhampton Ethics Committee by the CAAE number 12/18/NH/UOW.

Data collection
All participants attended two data-collection sessions: session one (baseline), pre-intervention, and session two, post-intervention, after three months (Figure 2).

[FIGURE 2 NEAR HERE]

At baseline (session one, pre-intervention), the participants completed the MDS-Unified Parkinson's Disease Rating Scale (UPDRS) – part III (motor symptoms) [25], the International Physical Activity Questionnaire (IPAQ) - short form [26], and the Hoehn & Yahr scale (H&Y) [27].

Also at baseline and three months just after intervention, while wearing the Xsens® full-body 3D motion suit (Enschede, Netherlands), all participants were asked to perform the TUG test twice: first, at a comfortable walking speed (Self-Selected Speed–SSS); and, secondly, as quickly and safely as possible (Fast Speed–FS).

The TUG test required participants to begin sitting on a chair with arms crossed in the chest, knees, hips and feet at 90° angle, with feet placed parallel. Participants were instructed to stand up, uncrossing the arms, walk a distance of 3 meters, pass around a cone (180° turn), return and sit back in the chair crossing the arms in the chest [28]. Following the clinical protocol of the TUG test, the participants performed the test once at SSS and once at FS, wearing their regular footwear and with no physical assistance.
The performance of the TUG test was recorded with a Xsens® full-body 3D motion capture suit. The sum of 17 wired trackers were positioned on the head, sternum, pelvis, upper legs, lower legs, feet, shoulders, forearms and hands [29]. A calibration procedure in a known N-pose (arms neutral besides the body in an upright position) was performed to determine the orientation of the sensor modules with respect to the body segments [30]. The data was wirelessly transmitted to a laptop and recorded in Xsens MVN Studio version 4.3 at a sampling rate of 240 Hz.

All evaluations were conducted during the "ON" state, between one and three hours after taking anti-parkinsonian medications [31]. When performing the tests, the participants showed no signs of dyskinesia. To control possible motor fluctuations, we took pre- and post-intervention measurements at the same time of the day, while data collectors were blinded to the participants’ group. Explanation and familiarization of the tests were administered before data collection, and, during the tests, the evaluator used verbal commands to guide the participants.

Dance intervention
Following baseline measures, the DIG received 3 months dance intervention. Classes were specifically designed for PwP and were led by a qualified dance instructor experienced in teaching this population. The in-person dance classes were conducted in an appropriate room with chairs and ballet barres once a week. In addition, the participants received a CD containing a video of the recorded dance routine to be performed at home once a week. All participants verbally confirmed that they practiced dance classes at home once a week. The class typically included a warm-up (10-15 min.), barre ballet exercises (10-15 min.), general dance-related activities (15-20 min), and a cool-down (10-15 min).

Data processing
The number of steps (NS) and the total time taken to complete the 180° turning phase (TTP) of the TUG test were measured in both groups pre- and post-intervention using the Xsens MVN analyze software and inputted into excel for further post processing. The TUG test has different phases: sit-to-stand, gait-to-go, turning, gait-return, and stand-to-sit. In this study we focused exclusively on the 180° turning phase of the test.

For clarity we used the following definitions which fully encompass and objectively identify the turning motion that occurs between the straight-line walking
sections of the TUG test, as previously suggested [32]. The beginning of the turn phase started from the last heel-strike of the regular straight line walking pattern. The end of the turn was the final heel-off at the end of the turning motion, where the participant was ambulating in the opposite direction and prior to the cyclic straight line gait pattern resuming. The exact time points were taken from the peak anterior-posterior linear velocity of the lower leg data corresponding with the specific heel-strike and heel-off instances. An illustrative example is provided in figure 3.

[FIGURE 3 NEAR HERE]

The NS taken to complete the 180° turning phase of the TUG was measured as the number of heel contacts occurring during the total time of the turn. The TTP was calculated from the time of the beginning to the end of the 180° turning movement.

The secondary analysed outcome was the girdle dissociation, a selected biomechanics parameter. To obtain the value for the girdle dissociation, the difference between the orientation of the pelvis and the affected shoulder in the transverse plane, was calculated for each data point throughout the 180° turning phase of the TUG test. The range between the maximum and minimum dissociation angles was reported and further analysed.

Statistical analyses
Data normality was verified using the Shapiro-Wilk test. Independent T-test analysis was used to assess differences between demographic data and clinical characteristics at baseline. Cumming’s Estimation Plots were generated using the Estimation Stats app [33] to present the results of the NS and TTP at participant’s Self-Selected Speed (SSS) and Fast Speed (FS). Changes over time were calculated for each group (post-pre) using the Mann-Whitney Test. The Cohen’s d was used to predict effect interpreted as small d= 0.2, medium d=0.5, and large d=0.8, and 95% confidence intervals were presented.

Girdle dissociation was presented as difference (Δ) and percentage of change (%) from pre- to post-intervention. To further explore the biomechanics of the 180° turning phase of the TUG, the girdle dissociation data were described for each participant, pre- and post-intervention, at both participants’ speeds (SSS and FS). All
statistical analyses were carried out using SPSS version 23, and Microsoft Excel Program version 16.44. The significance level was set at p<0.05.

RESULTS

Demographic data and clinical characteristics
Table 1 shows the mean, standard deviation (SD) and p values of the demographic data and participants' clinical characteristics. At baseline, groups did not differ significantly in the age, time of the disease, H&Y scale and MDS-UPDRS – part III. Both groups included men and women, and the principal medications were levodopa and carbidopa. In both groups, approximately, half the participants had more symptoms on the right side. In the IPAQ questionnaire 50% of the CG and 29% of the DIG reported practicing vigorous exercises, and 100% of both groups reported practicing moderate exercise.

[TABLE 1 NEAR HERE]

Number of steps (NS) and total time of the 180° turning phase (TTP) of the TUG
Figure 4 presents the number of steps (NS) during the 180° turning phase of the TUG at SSS and FS for both DIG and CG. A statistical difference (p<0.05; CI= -0.98; 2.66), with a large ES (d=0.923) was found between the two groups at FS. No statistical difference between the two groups at SSS was found. However, more participants in the DIG reduced the NS compared to CG.

Figure 5 shows the TTP in the DIG and CG, pre- and post-intervention, for the two speeds (SSS and FS). No statistical difference was found between the two groups, pre- and post-intervention, at SSS. However, at FS, the DIG became more homogeneous, and reduced the 180° turn time compared to the CG, showing a medium effect size (d=0.65) post-intervention period.

[FIGURE 4 NEAR HERE]

[FIGURE 5 NEAR HERE]
Girdle dissociation

Table 2 shows the girdle dissociation between pelvis and affected shoulder for each participant, the angular difference (Δ) and percentage (%) change, pre- and post-intervention, at both speeds (SSS and FS), during the 180° turning phase of the TUG. At SSS, post-intervention, the girdle dissociation between pelvis and affected shoulder was reduced in 4 DIG participants (0.45 to 5.84°; 4 to 47%), increased in 2 (-2.10 and -16.15°; 15 and 183%), and remained unchanged in 1 (0.49°; 3%). For the control group, the dissociation was reduced in 4 participants (0.95 to 5.62°; 8 to 25%), increased in 3 (-2.61 to -12.77°; 5 to 57%), and unchanged in 1 (0.33°; 3%).

[FIGURE 6 NEAR HERE]

At FS, post-intervention, 4 participants for the DIG reduced (5.23 to 18.34°; 17 to 39%) the girdle dissociation (5.23 to 18.34°; 17 to 39%) and 3 participants increased the dissociation (-9.78 to -14.84°; 76 and 103%); whilst the control group noted the girdle dissociation increased for 4 participants (-2.61 to -12.77°; 7 to 95%), remained unchanged for 3 (-0.12 to 0.43°, 1 to 2%) and decreased in 1 participant (2.54°; 10%).

[FIGURE 7 NEAR HERE]

Figure 6 and 7 show examples over the time course during the 180° turning phase of the TUG test at both speeds (SSS and FS) for the DIG and CG respectively. The orientation of the pelvis (blue line) and affected shoulder (orange line) in the transverse plane, pre- (continuous line) to post-intervention (dashed line). For the DIG, the pattern of the girdle dissociation between the pelvis and shoulder in the transverse plane can be seen to decrease after the dance intervention at both speeds (SSS and FS) with the “en bloc” pattern being more notable at FS. The lack of change in girdle dissociation for the CG group is highlighted in figure 7.

[FIGURE 7 NEAR HERE]
DISCUSSION

The main aim of this investigation was to investigate the effects of a dance intervention on the NS and the time taken to complete the 180° turning phase (TTP) during the TUG test in PwP. A secondary aim was to describe individual changes in the affected shoulder and pelvic girdle dissociation. We found that the functionality at SSS were not altered after dance intervention. However, the selected functional parameters improved in the DIG at FS, reducing significantly the NS with a large effect size, and TTP with a medium effect size. During the 180° turn performance, individual changes happened in the DIG, adjusting the girdle dissociation, and most participants turned more “en bloc” at both speeds.

Enriching our understanding on elements associated with turning movement may provide new insights into a common everyday motor task that is essential for functional mobility in PwP. Walking speed in PwP is significantly different than healthy individuals, particularly during turning tasks [34], with more steps being required to complete a turning movement [8, 35]. The present data have shown that dance could benefit PwP in improving basic temporospatial aspects of turning, such as the NS and TTP, enabling them to better perform an essential daily task. These results are in agreement with the current literature showing the positive effects of dance in PwP for clinical measures of functional mobility [14, 16].

In the DIG, the improvement in the 180° turn performance, reducing the NS and TTP at FS, might represent improvements in motor control related to task performing and auditory cueing. The basal ganglia, which are affected in PD, have been shown to be involved in the execution of automatic and repetitive movement [36], controlling motor sequences. In PD, basal ganglia circuitry dysfunction may be relevant in locomotion, leading to difficulty of turning and stop, among others [37, 38]. In particular, the putamen is involved with the sequencing of rhythmic events [39] and Pallido-thalamic pathways may influence the timing of the inter-segmental coordination for gait [46]. Thus, during dance classes, the use of the music could be considered a form of auditory cueing, providing an external rhythm that might compensate the defective internal rhythm of the basal ganglia circuitry in PwP [40], helping to improve motor control as previously suggested [41, 42]. The multiple stops, starts and turns that are naturally present in dance can be seen as a form of functional mobility training for PwP, combined with group dynamics that are considered motivating, engaging and enjoyable.
The better performance during the 180° turning movement was based on individual changes in girdle dissociation (DIG, Table 2), by adopting person-specific pattern at both speeds. These results are in line with recent data [22] which also demonstrated individual changes and unique person-specific effects that dance can offer for PwP in the management of their ability to perform the turning movement. PD is a person-specific problem, with a multifaceted nature, and the medical management of PD is not a “one-size-fits-all” response [11, 43]. The results of this study embraced and focused on the person-specific, and how these concept influence PwP motor functionality, helping to improve health conditions and well-being.

It is noteworthy that the majority of the participants in the DIG turned more “en bloc”, reducing the dissociation between pelvis and affected shoulder during the 180° turning phase of the TUG, changing the girdle dissociation pattern (Δ positive) at both speeds. These results are in line with available data [23], showing the same phenomenon, and suggesting this may be a beneficial adaptation, being able to better coordinate axial and perpendicular segments. During dancing, the body changes direction in space with the help of music, incorporating weight transfer and shifting, challenging balance and coordination, and encouraging axial rotations of head, trunk and lower limbs during turning conditions.

This preliminary study highlights the potential that dance has as a complementary therapy to improve PwP turning performance. Particularly, our study shows specific adjustments on inter-girdle biomechanics and performance during a functional task performance in PwP. Keeping the above in mind, it is reasonable to assume that the present study has been influenced by methodological limitations such as the number of volunteers. To better understand the effects of dance on the 180° turn performance in PwP, further studies using larger sample sizes and longer interventions are needed.

CONCLUSIONS
The present data provide preliminary evidence that dance could improve selected functional turning parameters, particularly at faster speeds, by reducing the number of steps and the total time of the turn. Biomechanical adjustments adopted person-specific patterns for girdle dissociation. However, turning more “en bloc” became a strategy of most participants in the intervention group. These results have clinical
implications as the integration of dance interventions into rehabilitation programs should help PwP to improve functional mobility.

**Clinical Messages**
- This study addresses the effects of a dance-intervention on specific adjustments on inter-girdle biomechanics and performance during a functional task in PwP.
- The results are important for clinical rehabilitation and highlighted the importance of dance as a complementary therapy to improve PwP turning performance, leading to a better functional mobility.

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Not applicable.

**Author contributions**
ANH participated in the study design and writing, recruiting volunteers, data collection, evaluation, and analysis of the results.
TS participated in the study design, writing, and data analysis.
LAPT participated in the study design, writing, and data analysis.
MBF participated in recruiting volunteers, data collection, evaluation and writing.
FN participated in recruiting volunteers, data collection, evaluation and writing.
MSD participated in the writing and in the statistical analysis.
YK participated in the study design, writing, and data analysis.
MW participated in the study design, writing, and data analysis.
All authors read and approved the final manuscript.

**Competing interests**
The authors have no conflict of interest to declare.

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References


### Table 1 – Mean±SD and p values of the demographic data and participants’ clinical characteristic, gender, type of medication, affected side, and level of exercise

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>DIG (n = 7)</th>
<th>CG (n = 8)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>73 ± 2</td>
<td>64 ± 5</td>
<td>0.165</td>
</tr>
<tr>
<td>TD (years)</td>
<td>8 ± 5</td>
<td>6 ± 5</td>
<td>0.963</td>
</tr>
<tr>
<td>H&amp;Y</td>
<td>2 ± 0.5</td>
<td>2 ± 0.0</td>
<td>0.060</td>
</tr>
<tr>
<td>MDS-UPDRS III</td>
<td>34 ± 16</td>
<td>23 ± 11</td>
<td>0.207</td>
</tr>
<tr>
<td>Gender</td>
<td>4 women / 3 men</td>
<td>3 women / 5 men</td>
<td>NA</td>
</tr>
<tr>
<td>Medication</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Levodopa – Carbidopa</td>
<td>7 (86%)</td>
<td>8 (100%)</td>
<td>NA</td>
</tr>
<tr>
<td>Others</td>
<td>1 (14%)</td>
<td>0 (0%)</td>
<td>NA</td>
</tr>
<tr>
<td>Affected side</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right Side</td>
<td>4 (57%)</td>
<td>4 (50%)</td>
<td>NA</td>
</tr>
<tr>
<td>Left Side</td>
<td>3 (43%)</td>
<td>2 (25%)</td>
<td>NA</td>
</tr>
<tr>
<td>Both Sides</td>
<td>0 (0%)</td>
<td>2 (25%)</td>
<td>NA</td>
</tr>
<tr>
<td>Exercise</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vigorous</td>
<td>2 (29%)</td>
<td>4 (50%)</td>
<td>NA</td>
</tr>
<tr>
<td>Moderate</td>
<td>7 (100%)</td>
<td>8 (100%)</td>
<td>NA</td>
</tr>
</tbody>
</table>

Note: TD= time of the disease; Hoehn & Yahr (H&Y) Scale; MDS-Unified Parkinson’s Disease Rating Scale (UPDRS) part III (MDS-UPSDRS III); SSS- Self-selected speed; FS- Fast Speed; NA=not applicable; %= percentage. *Statistical difference (p<0.05)
Table 2 – Girdle dissociation (degree), angular difference ($\Delta$), % change, pre- and post-intervention, at SSS and FS, during the 180° turning phase of the TUG for the Dance Intervention (DIG) and control (CG) groups

<table>
<thead>
<tr>
<th>Group</th>
<th>Participant</th>
<th>Self-selected speed (SSS)</th>
<th>Girdle Dissociation (°)</th>
<th>Fast Speed (FS)</th>
<th>% change</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIG</td>
<td>1</td>
<td>14.26 16.35</td>
<td>-2.10 $\uparrow$</td>
<td>19.42</td>
<td>-14.84</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>11.61 11.16</td>
<td>0.45 $\downarrow$</td>
<td>12.03</td>
<td>3.25 $\uparrow$</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>8.84 24.99</td>
<td>-16.15 $\uparrow$</td>
<td>47.33</td>
<td>18.34 $\uparrow$</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>17.35 15.22</td>
<td>2.13 $\downarrow$</td>
<td>30.72</td>
<td>5.23 $\downarrow$</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>15.50 15.00</td>
<td>-0.49 $\uparrow$</td>
<td>24.29</td>
<td>5.25 $\downarrow$</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>15.68 12.11</td>
<td>-3.57 $\downarrow$</td>
<td>11.01</td>
<td>-11.31 $\uparrow$</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>12.54 6.70</td>
<td>5.84 $\downarrow$</td>
<td>11.01</td>
<td>-9.78 $\uparrow$</td>
</tr>
<tr>
<td>Control</td>
<td>8</td>
<td>11.67 10.72</td>
<td>0.95 $\downarrow$</td>
<td>18.46</td>
<td>-1.31 $\uparrow$</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>16.72 14.93</td>
<td>1.80 $\downarrow$</td>
<td>17.31</td>
<td>-2.46 $\uparrow$</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>13.10 17.41</td>
<td>-4.31 $\downarrow$</td>
<td>26.02</td>
<td>2.54 $\downarrow$</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>8.75 7.15</td>
<td>1.61 $\downarrow$</td>
<td>10.30</td>
<td>-0.97 $\uparrow$</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>10.16 9.83</td>
<td>0.33 $\downarrow$</td>
<td>13.15</td>
<td>-0.12 $\uparrow$</td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>22.93 17.31</td>
<td>5.62 $\downarrow$</td>
<td>24.51</td>
<td>0.43 $\uparrow$</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>22.40 35.17</td>
<td>-12.77 $\uparrow$</td>
<td>35.48</td>
<td>-0.65 $\uparrow$</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>17.98 20.60</td>
<td>-2.61 $\uparrow$</td>
<td>12.87</td>
<td>-12.16 $\uparrow$</td>
</tr>
</tbody>
</table>

Note: P: participant; $\Delta$ angular difference: $\downarrow$ reduced girdle dissociation (positive value); $\uparrow$ increased girdle dissociation (negative value); $=$ less than 5%.
Figures

Figure 1- Flowchart: sample selection process and participant’s inclusion

Enrollment

Assessed for eligibility (n=40)

Volunteers included (n=15)

Not included (n = 25)
- Did not meet inclusion criteria (n= 6)
- Declined to participate (n= 19)

Selectively recruited for Dance intervention group (n= 7)

Droppers (0)

Completed non-randomised trial (n= 7)

Included in Analysis (n= 7)

Allocation

Selectively recruited for Control group (n= 8)

Droppers (0)

Completed non-randomised trial (n= 8)

Included in Analysis (n= 8)
Figure 2 – Study timeline

SESSION ONE (Baseline)
- Familiarisation
- Baseline tests: MDS-UPDRS part III; IPAQ, H&Y TUG tests wearing
- Pre-intervention test: Xsens® full-body 3D motion suit

Recruitment and allocation groups → Dance Intervention (3 months) → SESSION TWO
Post-intervention test: T TUG tests wearing Xsens® full-body 3D motion suit
Figure 3 - 180° turning phase of the TUG test definition: a) last heel-strike of straight-line gait representing the 1st heel strike of the turn, b) final heel-off at the end of the turn

A) START OF TURN

B) END OF TURN
Figure 4 – DIG and CG number of steps (NS) during the 180° turning phase of the TUG, pre-and post-intervention, at SSS and FS

Note: DIG_SSSpre= dance group pre in SSS; CG_SSSpre= control group pre in SSS; DIG_SSSpost=dance group post in SSS; CG_SSSpost= control group post in SSS; DIG_FSpre= dance group pre in FS; CG_FSpre= control group pre in FS; DIG_FSpost= dance group post in FS; CG_FSpost= control group post in FS; *p<0.05.
Built on https://www.estimationstats.com (Ho et al., 2019)
**Figure 5** – DIG and CG total time taken to complete the 180° turning phase (TTP) of the TUG, pre- and post-intervention, in SSS and FS

![Figure 5](image-url)

**Note**: DIG_SSSpre= dance group pre in SSS; CG_SSSpre= control group pre in SSS; DIG_SSSpost=dance group post in SSS; CG_SSSpost= control group post in SSS; DIG_FSpre= dance group pre in FS; CG_FSpre= control group pre in FS; DIG_FSpost= dance group post in FS; CG_FSpost= control group post in FS; *p<0.05.

Built on [https://www.estimationstats.com](https://www.estimationstats.com) (Ho et al., 2019)
Figure 6 – Example for the time course during the 180° turning phase of the TUG at both speeds (SSS and FS), showing the orientation of the pelvis (blue line), and affected shoulder (orange line) in the transverse plane.

Note: Pelvis pre: ; Shoulder pre: ; Pelvis post: ; Shoulder post:
Figure 7 – Example for the time course during the 180° turning phase of the TUG at both speeds (SSS and FS); showing the orientation of the pelvis (blue line), and affected shoulder (orange line) in the transverse plane.

Note: Pelvis pre: ; Shoulder pre: ; Pelvis post: ; Shoulder post: 