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Faculteit Revalidatiewetenschappen

master in de revalidatiewetenschappen en de kinesitherapie

Masterthesis

Art for MS: Effects of a 10 week multimodal dance and art intervention program on fatigue, fatigability and their related factors - A controlled pilot-trial

Sofie Cardeynaels
Katrien Van den Broeck

Scriptie ingediend tot het behalen van de graad van master in de revalidatiewetenschappen en de kinesitherapie, afstudeerrichting revalidatiewetenschappen en kinesitherapie bij neurologische aandoeningen

PROMOTOR :
Prof. dr. Peter FEYS

COPROMOTOR :
Mevrouw Fanny VAN GEEL

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We would like to express our deepest gratitude and appreciation to our promotor Prof. Dr. Peter Feys and our co-promotor Dra. Fanny Van Geel of Hasselt University for their guidance and for sharing their knowledge during the past two years. Also a special thanks to Dra. Renee Veldkamp for the assistance during the measurements.

We truly thank the organisation *Move to Sport vzw* for the collaboration and the participants for their enthusiastic spirits and participation in our research. Furthermore, we want to congratulate them on their performances of *Art for MS* which was a great success.

Aarschot (BE), 03/06/2019 K.V.d.B.

As (BE), 03/06/2019 S.C.

Inhoud

Research context

The subject of this master thesis fits in the research domain of neurological rehabilitation. Persons with MS (pwMS) often suffer from motor and cognitive disabilities, but one of the most disabling symptoms is fatigue. Fatigue can have many effects on a person's quality of life and active lifestyle. Fatigability is a part of the term fatigue which is effort dependent and thus can be influenced by activity. Fatigability, like fatigue, has a motor and a cognitive component and can therefore be influenced on many levels.

This research focuses on whether fatigability and fatigue can be improved using a multimodal approach, such as a choreographed dance intervention. Furthermore, the effects on physical capacity such as gait, strength, coordination and balance; cognitive capacity such as working memory; dual tasking; sensory function and health-related quality of life are investigated.

This master thesis is situated within an ongoing research project of the PhD student Fanny Van Geel, our co-promotor. Her work focuses on investigating motor fatigability during walking and aims to investigate an efficient intervention. As the relation between cognitive fatigability and motor fatigability seems to be present in patients with MS, a combination of a cognitive and a motor intervention is needed. The effect of music combined with multimodal motor exercises, and cognitive tasks, such as used in choreography dancing, could be a feasible and enjoyable rehabilitation form for pwMS that primarily show walking fatigability.

This thesis has been a duo-master thesis were both students worked together on writing the paper and to participate in the research process.

The design and method of this research was determined by our co-promotor, so the students had no part in this decision.

The research of this pilot study started in August, after the approval of the Medical Ethics Committee. The recruitment of the participants was organised by our co-promotor. After the baseline testing, the intervention started mid-September. Because this research was an ongoing project of our co-promotor, the intervention was given by our co-promotor, a professional dancer. Both students attended the dance training sessions once a week for assistance and observation. The intervention ended with a live performance on stage in Antwerp which the students also attended for assistance.

The data acquisition of the baseline and post testing was done by the students with help from the co-promotor and another therapist.
The data processing was done by the student Katrien Van den Broeck with assistance of the promotor and co-promotor.
The interpretation of the results was written by the student Sofie Cardeynaels and she made the tables and figures.
The discussion was written by Sofie Cardeynaels with assistance of Katrien Van den Broeck.
Both students worked together on writing the introduction and the methods section.
The full thesis was written independently by both students but was revised by the co-promotor and promotor.

The live performance (Art for MS) was organised by Move to Sport vzw. It is a non-profit organisation that promotes an active lifestyle in persons with MS and is directed by Paul Van Ash. This organisation has already organised many great events to support persons with MS in the past. For example, MS versus Mont Ventoux in 2017, MS Petra in 2014 and MS Machu Picchu in 2012. They also provide workshops and courses for physiotherapists to teach them to become qualified professionals that develop special skills in guiding persons with MS.
The performance of Art for MS on November 16th, 2018 was such a great success that extra performances were scheduled on February 2nd and May 29th, 2019. (https://www.movetosport.be)

Article

Art for MS - Effects of a 10-week multimodal dance and art intervention program on fatigue, fatigability, and their related factors. - A controlled pilot-trial.

ABSTRACT

Background: Fatigue, as reported by 40-80% of people with Multiple Sclerosis (pwMS), is often an important disabling symptom. Dance therapy improves motor and cognitive function in patients with other neurological disorders and elderly but the effects on fatigability and fatigue have not been investigated. The effects of exercise therapy in pwMS are extensively researched but the evidence of dance therapy is limited.

Objectives: The aim of this pilot study is to investigate whether a ten-week choreo-based dance intervention has positive effects on fatigability and fatigue, physical and cognitive capacity, sensory function, health-related quality of life (HR-QoL) and dual tasking in pwMS.

Participants: 17 participants, between 18 and 70 years, with MS were allocated into a dance group (DG) and an art group (AG) for a ten-week intervention program which ended with a live performance. The DG had a choreo-based dance intervention, while the AG contributed to the art production in other various ways.

Measurements: Measurements took place before the intervention and after the live performance. Six categories were investigated. Fatigue-related outcome measures, physical capacity, sensory function, cognitive capacity, HR-QoL and dual tasks. Statistical analysis is executed with the SPSS statistical program.

Results: The DG improved significantly on five times sit-to-stand (5STS), nine-hole peg test (NHPT), Activities-specific balance confidence scale (ABC), MS walking scale (MSWS-12), modified Fatigue Impact Scale (MFIS), Paced auditory serial addition test (PASAT) and dual tasks. The AG improved significantly on MFIS and dual tasking.

Conclusion: A ten-week multimodal dance intervention has positive effects on fatigue, physical capacity, cognitive function and dual tasking. Further research in larger samples in this domain is recommended.

INTRODUCTION

Multiple Sclerosis (MS) is an autoimmune disorder characterized by destruction of myelin in the central nervous system. Common symptoms include visual, motor, sensory or bladder dysfunctions. Fatigue, as reported by 40-80% of people with MS (pwMS), is often an important disabling symptom (Kluger, Krupp, & Enoka, 2013).

Fatigue can be described as the subjective perception of weariness (Kluger et al., 2013). It can be divided into two domains: trait and state fatigue. Trait fatigue is the long-term characteristic which is effort-independent and thus always present. State fatigue or fatigability is effort-dependent and thus activity-based. Both can be subdivided into a motor and cognitive domain. Motor fatigue/fatigability is characterised by motor weakness whereas cognitive fatigue/fatigability is the inability to sustain a mental task. In fatigability**,** both domains have a perceived, what the patient experiences, and a performance, what can be measured objectively during or after a certain task, component (Chaudhuri & Behan, 2000; Kluger et al., 2013). Moreover, motor and cognitive fatigability are shown to be correlated (Spiteri, Hassa, Claros-Salinas, Dettmers, & Schoenfeld, 2019). In addition, fatigue is inversely correlated with the QoL. The more fatigue is experienced, the greater the reduction in the QoL (Motl & McAuley, 2010).

PwMS also suffer from walking disabilities. The reduction of the walking capacity in pwMS is related to a reduction in lower limb performance and balance (Brincks, Andersen, Sorensen, & Dalgas, 2017; Broekmans et al., 2013; Kalron, Achiron, & Dvir, 2011). The lack of lower limb performance is often the result of primary motor impairments e.g. hypertonia, muscle weakness and coordination problems which might be related to fatigue and fatigability (Thickbroom, Sacco, Faulkner, Kermode, & Mastaglia, 2008).

Leone et al. (2016) investigated the individual occurrence of walking-related motor ability according to the MS phenotype and disability level in pwMS. This study shows an increase in prevalence up to 50% of walking-related motor fatigue, measured by the Distance Walking Index (DWI), when pwMS were more disabled (Expanded Disability Status Scale, EDSS ≥ 4).

In addition, upper limb dysfunctions are also common in pwMS (Kister et al., 2013). Upper limb dysfunctions can affect tactile sensitivity, muscle strength and the ability to manipulate objects (Bertoni, Lamers, Chen, Feys, & Cattaneo, 2015).

Besides motor deficits and fatigability or fatigue, cognitive dysfunctions and cognitive fatigue or fatigability are experienced. Up to 75% of people with MS suffer from cognitive impairment in all stages of the disease process (Trenova et al., 2016). Processing speed and memory are most frequently affected (Langdon, 2011) but executive functions and learning can deteriorate as well.

All these impairments have a negative impact on the ADL of pwMS (Chiaravalloti & DeLuca, 2008; Lamers et al., 2015; Wolkorte, Heersema, & Zijdewind, 2015).

PwMS intend to engage in less physical activity in comparison with healthy people (Motl, McAuley, & Snook, 2005). Endurance training, strength training, mixed training, task-oriented training or other interventions such as yoga can be safely administered (Heine, van de Port, Rietberg, van Wegen, & Kwakkel, 2015). Furthermore, balance and mobility seem to improve after dual-task training. However, dual-task training is not superior to single balance training (Monjezi, Negahban, Tajali, Yadollahpour, & Majdinasab, 2017).

The effects of exercise therapy in pwMS are extensively researched. Exercise therapy seems to improve trait fatigue (Heine et al., 2015). However, it is often a secondary outcome measure and the treatment is not always addressed to fatigue or fatigability. In contrast, only one study has investigated the effects of dance therapy in pwMS (Mandelbaum, Triche, Fasoli, & Lo, 2016).

Regular participation in dance classes results in higher cognitive, motor and sensory functions in older individuals (Kattenstroth, Kalisch, Holt, Tegenthoff, & Dinse, 2013). It can be stated that dancing has characteristics of a motor-cognitive dual task training (Hamacher, Hamacher, Rehfeld, Hokelmann, & Schega, 2015; Hamacher, Hamacher, Rehfeld, & Schega, 2016). Many partnered dance therapies have been researched among the elderly population and people with neurological disorders such as Parkinson disease. But individual choreo-based dance therapy has not been intensively researched.

So far, Mandelbaum et al. (2016) examined the effects and tolerability of structured salsa dance therapy for pwMS. This study concluded that the effects of dance therapy may improve physical activity, gait and balance in pwMS. Dance therapy improves motor and cognitive function in patients with other neurological disorders and elderly but the effects on fatigability and fatigue have not been investigated.

Therefore, the aim of this trial is to investigate whether a choreo-based dance intervention has positive effects on fatigability and fatigue in pwMS. Secondly, the additional effects of this intervention on walking capacity, cognition, upper and lower limb function, sensory function, dual tasking and quality of life (QoL) will be investigated.

METHODS

This clinical study was a collaboration between *Move to Sport vzw* and Hasselt University and has been approved by the UHasselt Medical Ethics Committee (B9115201836892; 03/07/2018).

The study is conducted according to the guidelines of the International Conference of Harmonization (ICH) Good Clinical Practice (GCP) and according to the latest version of the Helsinki Declaration composed to protect people participating in clinical trials.

Participants

Recruitment and patient demographics

Patients were recruited via Move to Sport, a non-profit association connected to Hasselt University, and a private practice in Kontich (Antwerp, Belgium) that helps people with MS to have an active lifestyle.

Inclusion criteria were (a) a confirmed diagnosis of MS according to McDonald criteria, (b) aged 18-70 years and (c) able to walk independently or with bilateral support for six minutes without rest. Participants were excluded when an exacerbation occurred in the last three months before the onset of the study or if they suffered from other medical conditions that interfere with walking ability (e.g. cardiac or respiratory disease, arthritis, fibromyalgia, Parkinson's Disease, stroke, …).

Group allocation

Participants were allocated into two groups. The dance group (DG) performed ten weeks of choreographed dance training, while the art group (AG) contributed in various forms of art (word art, painting, photography, music or film) for ten weeks. The allocation was determined according to the leisure preferences of the participants.

Procedures

Intervention

The dance group and the art group contributed to a conceptual art production, with Multiple Sclerosis as theme subject, in which the participants had to perform live on stage. Both interventions were administered by the same trainer.

The intervention of the dance group consisted of a choreo-based dance therapy. The dance classes were organised twice per week for ten weeks. Each session consisted of a ten-minute warm up, 70 minutes of training and a ten-minute cool down. The participants were taught three choreographies. The first choreography consisted of floor work on a slow rhythm. It focussed on proprioception, stretching, abdominal muscle strength, coordination and working memory. The second choreography was also slow paced and consisted of a group part and a canon part which triggered the inhibition ability of the brain. In general, the choreography aimed to improve working memory, static and dynamic balance and strength. The third choreography had a higher rhythm and was danced with a cane which required more coordination. Furthermore, it required dynamic balance, speed and cognition. The choreographies were based on the music, so the participants had to rely on the rhythm of the music instead of counting the steps to make it more challenging. Also, the choreographies were built up by grade of difficulty during the ten-week intervention. The latter were more complex in balance, strength, endurance, coordination and cognition.

The art group contributed to the production in various ways. Four participants recited about the pathophysiology of MS and about their own experiences with the disease in a poetic and dictive manner based on their self-made script. Four participants created paintings about the symptoms of MS which were used in the background during the performance. Afterwards the paintings were displayed for the public. The other two participants were respectively a photographer and a videographer. They recorded the meetings and the performances of the dance and the art group. The art group had meetings of one-and-a-half hour, once per week. The artists discussed what their role would be in the production. They also had workshops with other artists on how to perform on stage. Once per week, if possible, they also had meetings at home with the painters and the reciters together.

The last three sessions of both groups were organised together to rehearse for the performance.

Outcome measures

As effects are expected on multiple physical and non-physical domains, outcome measures have been divided into six categories.

As a first category, fatigue related outcome measures are evaluated. This includes the distance walking index (DWI) for performance motor fatigability. The distance of first and last minute is used to calculate the DWI. (DWI = ([Distance walked at minute 6 – Distance walked at minute 1]/Distance walked at minute 1) × 100) (Leone et al, 2016). Besides the DWI, a Visual Analogue Scale (VAS) score will be taken at the start and at the end of the 6MWT to measure perceived motor fatigability (Lee KA, Hicks G, et al 1991). The Modified Fatigue Impact scale (MFIS) and the Fatigue Severity Scale (FSS) will be used for trait fatigue. The Physical subscale of the MFIS will be used to assess trait motor fatigue. Similar to the DWI, a cognitive fatigability index (CFI) will be calculated comparing the correct responses of the first third and the last third of the paced auditory serial addition test (PASAT) (([last ⅓ - first ⅓]/last ⅓) x 100) for performance cognitive fatigability (Morrow, Rosehart, & Johnson, 2015).

The second category is physical capacity and contains walking endurance, walking ability and capacity, balance, lower limb strength and manual dexterity. Walking endurance was measured by the 6MWT. Walking ability and capacity was measured by the MS walking scale (MSWS-12) and by the timed 25-foot walk test (T25FW). The activities-specific balance confidence scale (ABC) and the dynamic gait index (DGI) measured balance (Cattaneo, Regola et al 2006). Manual dexterity was evaluated using the nine-hole peg test (9HPT) (Feys P, Lamers I, et al 2017). The five times sit-to-stand (5STS) measured leg strength (Moller AB, Bibby et al, 2012).

Sensory function as third category was assessed by the Erasmus modified Nottingham Sensory Assessment (EmNSA).

The fourth category is cognitive capacity. This was measured by the number of correct answers on the symbol digit modalities test (SDMT) and the PASAT (Langdon, Amato et al 2012).

As a fifth category, the Health-related Quality of Life (HR-QoL) was measured by the MS Impact Scale (MSIS-29) and the Short Form Health Survey (SF-36).

The last category contains the dual tasks. It consists of one motor and two cognitive tasks. One dual task consisted of walking with a cup in combination with a word list generation task. The other dual task consisted of walking with a cup and a subtraction task. The Dual Task Cost (DTC) ((single task - dual task)/single task * 100) was calculated for both dual tasks to measure cognitive-motor interference (CMI).

Three test stations were put up. One station consisted of the SDMT, the PASAT and the 5STS. Another station tested the 9HPT, T25FW, EmNSA and the DGI. The last station tested the 6MWT and the motor and cognitive dual tasks. All the patient-reported questionnaires were handed to the participants for them to complete at home. The testing took place one to two weeks before the start of the intervention (baseline) and one to two weeks after the live performance (post-measurements). None of the assessors were blinded to group allocation. There was no follow-up measurement.

Data analysis

The data analysis was executed using the Statistics Package for Social Sciences program (SPSS) (Armonk, NY: IBM Corp.). The Shapiro-Wilk test for normality were performed for each group and variable to check for normal distribution. Non-parametric statistics were conducted. Between-group differences were analysed by the non-parametric Mann-Whitney U test to determine baseline differences. Within-group differences were analysed by the non-parametric Wilcoxon Signed Rank test comparing baseline data with post intervention. The significance level was set at $p < 0.05$.

RESULTS

Demographics

There were seven dancers in the DG and ten artists in the AG. There was one drop-out from the DG because of illness. The age of the participants ranged between 29 and 65 years. All but one from the AG were women. The onset of the disease varied from three years to 21 years. Most of the participants had relapse remitting MS. One of the participants did not know her subtype. Walking aids were used in the AG and DG. Two artists walked with a rollator, one walked with a crutch and one with a cane. One dancer walked with a cane. An overview of the demographics is listed in table 1.

All participants continued their usual physiotherapy apart from the intervention.

At baseline, the DG had significantly higher scores on EmNSA (sharp-dull discrimination) and the motor performance of the dual task carrying a cup and doing the subtraction task. Other outcome measures did not differ significantly. Baseline characteristics are depicted in table 2.

Fatigue-related outcome measures

The results of all outcome measures are depicted in table 3.

Distance-walked index

The analysis revealed no significant changes in DWI. At baseline, none of the dancers showed fatigability. At post testing the DWI improved in all but two participants. One of them had a decline from 5.88% to 11.58%, the other dancer showed a decline from 2.17% to 4.12%.

In the AG, two artists showed fatigability at the start of the intervention while only one artist was found to have a DWI of more than 15% at the end of the study. (Leone et al., 2016).

Modified fatigue impact scale – Physical subscale

The median scores of the physical subscale of the MFIS improved significant over time in both groups. All participants, apart from two, showed improvements after the intervention. Two participants showed no changes.

Modified fatigue impact scale – total

A significant main effect of time was found for the improvements in the DG. The median score decreased with 17 points. The improvements surpassed the cut off value (<38/84) indicating a low impact of fatigue.

The AG decreased with six points and this was found to be significant (p=0.005). The improvements did not meet the cut off value (>38/84) indicating a moderate impact of fatigue.

Fatigue Severity scale

The analysis could not reveal significant differences over time. Fatigue severity decreased in the DG while the median score of the AG increased. A lower value means less fatigue severity.

Visual Analogue Scale 6MWT

The analysis showed nonsignificant changes in VAS score. The DG showed less fatigue at the start and the end of the 6MWT post intervention. They improved from moderate fatigue to mild fatigue at the start of the 6MWT (Boonstra, Schiphorst Preuper, Balk, & Stewart, 2014).

The median VAS score of the AG did not differ after the intervention.

Cognitive fatigability index

Both groups showed improvements in the median cognitive fatigability index but again, the improvements were not significant. The DG had a score of 10% at baseline and 0% at post testing. The AG started with an index of 11.25% and decreased to 2.50%.

Physical capacity

6 Minute Walking Test

Both groups showed improvements, but the median distance walked did not change significantly over time. Two participants of the AG did not perform this test because of their walking disabilities.

Timed 25FT Walking test

Analysis of the T25FW did not reveal significant changes in the DG nor the AG. All participants, except for three in the AG, performed the test after the intervention in less than 8 seconds which is the cut off score for ambulatory difficulties. This indicates they had few ambulatory difficulties. One participant completed the test in 10 seconds and two participants did not perform this test because of their walking disabilities.

Dynamic Gait Index

The analysis revealed no significant changes in the scores of the DGI. The DG improved with one point while the median score of the AG declined with one point. The higher the score, the lower the risk of falls. The cut off is set at 12 points for pwMS (Cattaneo, Regola, & Meotti, 2006). A score below this value indicates high risk of falls. None of the participants scored below the cut off value.

In the AG there were three participants who did not perform this test.

5 Times Sit-to-Stand

The median time to perform the 5STS was found to be below the cut off value of 16 seconds in both groups which indicates a low risk of falls. The DG decreased their median time significantly with 2.49 seconds. The AG improved their median time with 0.58 seconds, but analysis proved to be nonsignificant.

Activities-specific Balance Confidence scale

A significant main effect of time was found in the DG with an improvement of 2%. The percentage after the intervention is above the cut off value of 67% which indicates a decrease in risk of falls. The AG improved with 6% but analysis appeared to be nonsignificant. They appeared to be more confident than the DG.

12-item MS Walking scale

With a decrease of 10%, the DG showed a significant improvement over time on the MSWS-12 ($p=0.046$). The analysis of the AG showed a nonsignificant increase in median score.

Nine Hole Peg Test

In the DG, all the participants were righthanded. A significant improvement ($p=0.018$) was found for the dominant hand. The postintervention time was below the cut off score of 18 seconds which differentiates between normal and abnormal hand function. This indicates that the DG went from an abnormal hand function to a normal hand function. No significant changes were found for the nondominant hand in the DG nor for both hands in the AG.

Sensory Function

Erasmus modified Nottingham Sensory Assessment

Both groups performed a maximum score of 48 points on tactile function and this remained after the intervention. This created a ceiling effect for both groups. Consequently, statistical analysis could not detect significant changes.

Sharp-dull discrimination deteriorated in both groups, but the decline was not found to be significant within the groups. The between-group difference was found to be significant at baseline and post intervention in favour of the DG. The median score of proprioception decreased with one point in the DG and increased with half a point in the AG but both progressions appeared to be nonsignificant. Higher scores indicate better sensation.

Cognitive capacity

Symbol digit modalities test

The improvements of the DG on the SDMT were small and statistical analysis appeared to be nonsignificant. Conversely, the analysis in the AG revealed significant improvements in number of correct answers.

Paced auditory serial addition test

The median scores of the PASAT improved in both groups. In the DG the improvement of six points showed a tendency towards a significant improvement (p=0.068). The analysis in the AG showed no significant improvements.

Health-related QoL

MS Impact Scale - 29

The analysis showed no significant improvement in MSIS score in the DG. The AG improved their median score with one point but again was not proven to be significant. The between-group analysis showed a significant difference in advantage of the DG.

Short form-36 health survey

No significant differences were found. Both groups showed improvements in mental component score (MCS). The DG improved from average to above average after the intervention. The AG improved but remained in the average category which points to a good mental health.

The physical component score declined in the DG to below average which indicates a poor physical health. The AG improved with one point, but it remains below average and is worse than the DG.

Dual tasks

Dual task performance

These scores indicate the absolute values of the distance they could walk and the number of correct answers they could give on a cognitive task under dual task conditions. Statistical analysis revealed improvements in de median scores of all the motor and cognitive tasks in the dance and art group. Only the number of words during the word list generation and carrying a cup were found to improve significantly in both groups.

Dual task cost

The dual task cost (DTC) of the motor tasks are deteriorated in comparison with the baseline. However, the DTC of the DG does not rise above 10% after the intervention which indicates little interference. The DTC in the AG is higher than 10% before and after the intervention which indicates a moderate interference from the dual task.

The DG had small interference during the subtraction task at baseline, but it improved even more after the intervention. However, these improvements were not found to be significant.

The AG deteriorated in the DTC of the subtraction task after the intervention but improved in the DTC of the word list generation. However, analysis could not reveal significant improvements.

DISCUSSION

A ten-week multimodal choreo-based dance program seems to have significant effects on fatigue, lower limb strength, self-reported balance, hand function, the impact of MS on walking abilities and cognitive function. This is in line with the findings of Mandelbaum et al. (2016). A ten-week art intervention also shows significant improvements in fatigue and dual tasking.

Mandelbaum et al. (2016) found significant improvements in DGI and ABC after a four-week dance intervention. Also, they found significant improvements in MSWS-12 at follow-up. The lack of a control group was a shortcoming. The current study could not reveal significant changes in DGI. A possible explanation is that the salsa choreographies were more challenging for balance. Salsa dance consist of spins with head turns and part of the DGI evaluates turning and walking with head turns.

The effects of creative art programs in pwMS have been investigated by Fraser and Keating (2014) and Hunt, Nikopoulou-Smyrni, and Reynolds (2014). They found improvements in QoL and self-efficacy. The AG in the current study also improved in QoL but improvements were negligible. The improvements in self-reported outcome measures were expected to be greater because of the group dynamics. The artists enjoyed working together during the sessions and the live performance.

The improvements are considered clinically meaningful as they are greater than the minimal clinical important difference (MCID). The 5STS improved significantly in the DG and exceeded the MCID of 2.3 seconds (Meretta, Whitney, Marchetti, Sparto, & Muirhead, 2006). Both groups improved significantly on the MFIS, the physical subscale and the total score. However, the improvements were only clinically relevant in the DG with improvements greater than the MCID of respectively 24.5% and 19.3% (Rietberg, Van Wegen, & Kwakkel, 2010). Also, the total score of the AG did not improve below the cut off value of 38/84 which means a moderate impact of fatigue. Although the impact of fatigue diminished, there were no significant improvements in severity of fatigue. A possible explanation is that the participants wanted to deliver a good performance. They experienced fatigue during the training sessions, but the performance kept them motivated to keep on training.

The improvement of 11 points on the MSIS-29 in the DG also exceeded the MCID (Costelloe et al., 2007) but it was not significant. Both groups did differ significantly on the MSIS-29 after the intervention in favour of the DG. This is probably due to differences in motivation and a more active lifestyle in the DG. The AG had more participants with walking aids, while in the DG only one participant used a cane during her daily life activities. Also, there was a significant difference in the age of both groups. The DG is remarkably younger than the AG. This can be a confounding factor because younger people are expected to have a better physical and cognitive capacity.

It is important to note that not all participants were taken into the analysis for all outcomes (table 4). Three artists were excluded from the 6MWT and its related outcome measures. They could not participate to the test because of their walking disabilities. This also applies to the DGI. Two artists were not taken into the analysis for the T25FW, 5STS and the dual tasks because of their walking disabilities.

On the total score of the PASAT, one dancer had to be excluded because she started laughing in the middle of the test. Although, a cognitive fatigability index was calculated because she did complete the first and third section of the PASAT. Also, one artist mentioned during the baseline assessments that she recently lost a family member so this could have had an impact on her physical and mental performances and perceptions.

There are some limitations. First, the aim was also to investigate the effects of dance on lower limb coordination. This was measured at baseline and post intervention with an especially developed coordination chair but because of technical issues, the data could not be extracted. Secondly, during baseline testing, all participants took the tests in a fixed order. At post intervention this order could not always be maintained. This could also explain differences in post testing scores. Thirdly, the groups were not completely similar at baseline especially for age. Fourthly, the participants were not randomised and could not be blinded for the intervention.

Lastly, a follow-up measurement could not take place because extra live performances were scheduled. For these performances, extra training sessions were organised. This would have influenced the follow-up assessments.

The strength of this study is that this is the first study investigating a choreo-based dance intervention in pwMS. Many outcome measures have been investigated and show promising results.

Future Recommendation

This study can serve as a guide for further research in this domain. In the future, larger sample sizes must be included to create a greater power of the study. Also, coordination should be included as this is an important outcome measure to investigate in a dance intervention.

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Appendix

Table 1:
Participant demographics

	DANCE	ART	p-value
N	7	10	/
Female/male ratio	7/0	9/1	0.403
Age range	29 – 52 years	40 – 65 years	0.040*
Years since diagnosis	3 – 21 years	6 – 21 years	0.921
Walking aids	Cane (n=1)	Rollator (n=2), crutch (n=1), Cane (n=1)	/

Table 2:
Baseline characteristics: median values

	Fatigue & Fatigability							Physical Capacity								Sensory Function		
	DWI	MFIS-physical (./36)	MSIS – total (./84)	FSS (./7)	VAS 6MWT start (./10)	VAS 6MWT end (./10)	CFI (%)	6MWT (m)	T25FW (S)	DGI (./24)	5STS (s)	ABC (%)	MSWS-12 (%)	NHPT – dominant (s)	NHPT – non dominant (s)	EmNSA – touch (./48)	EmNSA – sharp/dull (./16)	EmNSA – proprioception (./16)
DANCE	-5.88	19	43	5	4	6	10	473	4.90	21	11.86	66	55	20.76	22.96	48	15	16
ART	-3.03	24.50	47.50	4.78	2	4	11.25	544	5.10	22	10.15	71	60	19.47	20.85	48	12	15.50
p-value	0.728	0.078	0.118	0.883	0.598	0.559	0.623	1.00	0.907	0.846	0.908	0.494	0.732	0.329	0.922	0.223	0.009*	0.619

*p<0.05

6MWT: six minute walking test; T25FW: timed 25 feet walk test; DGI: Dynamic gait Index; 5STS: five times sit-to-stand; ABC: activities-specific balance confidence scale; MSWS-12: 12 item Multiple sclerosis walking scale; NHPT: nine hole peg test; DWI: distance walking index; MFIS: modified fatigue impact scale; FSS: fatigue severity scale; VAS: visual analogue scale; CFI: cognitive fatigability index; EmNSA: Erasmus modified Nottingham sensory assessment

Table 2:
Continued

	Cognitive Capacity		HR-QoL			Dual task performance				Dual Task Cost			
	SDMT	PASAT	MSIS-29 (./100)	SF36 – PCS (./100)	SF36 – MCS (./100)	DT – motor cup & subtraction (m)	DT –cognitive cup & subtraction (amount)	DT – motor cup & WLG (m)	DT – cognitive cup & WLG (amount)	DTC - motor cup & subtraction (%)	DTC - cognitive cup & subtraction (%)	DTC - motor cup & WLG (%)	DTC - cognitive cup & WLG (%)
DANCE	64	49	59	51.97	42.27	68	13	62	11	3.23	6.67	7.63	23.08
ART	53	48.50	80.50	54.84	33.68	60.50	14.25	65.50	11	14.38	5.63	12.78	17.19
p-value	0.118	0.922	0.097	0.143	1.00	0.049*	0.862	0.355	0.772	0.772	0.862	0.862	0.816

*p<0.05

SDMT: symbol digit modalities test; PASAT: paced auditory serial addition test; MSIS-29: 29 item Multiple sclerosis impact scale; SF36: short form 36 health survey; PCS: Physical component score; MCS: mental component score; DT: dual task; DTC: dual task cost; WLG: word list generation

Table 3:
Results

Outcome	Group	Baseline Median (IQR)	Post-intervention Median (IQR)	Within group p-value	Between group post p-value
Fatigue and fatigability					
DWI (%)	DANCE	-5.88 (-9.46; -2.17)	-4.12 (-5,88; 0.00)	0.866	1.000
	ART	-3.03 (-12.96; -1.10)	-5.10 (-8.11; 0.00)	0.735	
MFIS – Physical (./36)	DANCE	19 (8; 24)	13 (3;20)	0.018*	0.141
	ART	24.50 (19.75; 30.00)	19.50 (12.75; 22.75)	0.012*	
MFIS – total (./84)	DANCE	43 (19; 48)	26 (6; 49)	0.034*	0.187
	ART	47.50 (41; 53.75)	41.50 (27.75; 47)	0.005*	
FSS (./7)	DANCE	5 (3.98; 5.22)	3.78 (3.33; 5.22)	0.310	0.329
	ART	4.78 (4.05; 5.35)	4.84 (4.53; 5.33)	0.722	
VAS 6MWT start (./10)	DANCE	4 (1; 4)	2 (1; 5)	0.673	0.795
	ART	2 (1; 3)	2 (1; 4)	0.414	
VAS 6MWT end (./10)	DANCE	6 (1; 7.5)	4 (2; 6)	0.671	0.700
	ART	4 (3; 8)	4 (3; 8)	0.180	
CFI (%)	DANCE	10 (0.00; 13.33)	0 (-5.26; 18.18)	0.249	0.922
	ART	11.25 (-6.33; 25.88)	2.50 (-7.28; 17.73)	0.445	
Physical Capacity					
6MWT (m)	DANCE	473 (414; 567)	483 (394; 561)	0.352	0.565
	ART	544 (382;577)	547 (414;574)	0.310	
T25FW (s)	DANCE	4.90 (4.30; 5.60)	4.90 (4.10; 5.60)	0.197	0.815
	ART	5.10 (3.75; 6.48)	4.70 (4.25; 5.95)	0.575	
DGI (./24)	DANCE	21 (18; 23)	22 (17;24)	0.891	0.797
	ART	22 (18; 23)	21 (18; 23)	0.480	
5STS (s)	DANCE	11,86 (8.12; 12.38)	9.37 (8.58; 10.08)	0.043*	0.728
	ART	10.15 (7.19; 20.63)	9.57 (7.63; 12.82)	0.161	
ABC (%)	DANCE	66 (40; 100)	68 (62; 100)	0.043*	0.769
	ART	71 (40.75; 80.25)	77 (60.75; 87.25)	0.333	
MSWS-12 (%)	DANCE	55 (32; 75)	45 (25; 48)	0.046*	0.261
	ART	60 (31.50; 85.75)	65 (26; 92)	0.207	
NHPT – dominant (s)	DANCE	20.76 (19.25; 25.11)	17.87 (18.81; 17.37)	0.018*	0.626
	ART	19.47 (18.20; 23.24)	18.35 (15.86; 25.42)	0.683	
NHPT – non dominant (s)	DANCE	22.96 (19.88; 24.03)	21.21 (17.16; 25.14)	0.237	1.000
	ART	20.85 (17.35; 28.57)	19.86 (18,55; 25,65)	0.333	

*p<0.05
°p≈0.05
6MWT: six minute walking test; T25FW: timed 25 feet walk test; DGI: Dynamic gait Index; 5STS: five times sit-to-stand; ABC: activities-specific balance confidence scale; MSWS-12: 12 item Multiple sclerosis walking scale; NHPT: nine hole peg test; DWI: distance walking index; MFIS: modified fatigue impact scale; FSS: fatigue severity scale; VAS: visual analogue scale; CFI: cognitive fatigability index;

Table 3:
Continued

Outcome	Group	Baseline Median (IQR)	Post-intervention Median (IQR)	Within group p-value	Between group post p-value
Sensory Function					
EmNSA – touch (./48)	DANCE	48 (48; 48)	48 (48; 48)	0.317	0.250
	ART	48 (45; 48)	48 (31.25; 48)	0.066°	
EmNSA – sharp/dull (./16)	DANCE	15 (13; 15)	14 (13; 16)	0.480	0.029*
	ART	12 (10; 14)	11.50 (10; 13.25)	0.722	
EmNSA – proprioception (./16)	DANCE	16 (14; 16)	16 (16; 16)	0.157	0.065°
	ART	15.50 (14.75; 16)	16 (15; 16)	1.000	
Cognitive Capacity					
SDMT	DANCE	64 (56; 80)	65 (40; 82)	0.917	0.305
	ART	53 (42; 63.50)	60.50 (50; 64.50)	0.068°	
PASAT (./60)	DANCE	49 (39; 57.75)	55 (41.75; 60)	0.036*	0.662
	ART	48.50 (41.50; 54.25)	52.50 (44; 58)	0.085	
Health-related QoL					
MSIS-29 (./100)	DANCE	59 (34; 82)	48 (33; 61)	0.063°	0.025*
	ART	80.50 (58; 93.25)	79.50 (56; 88)	0.374	
SF36 – PCS (./100)	DANCE	51.97 (31.21; 48.11)	61.21 (30.42; 52.19)	0.499	0.435
	ART	54.84 (27.90; 38.26)	58.76 (27.90; 38.26)	0.169	
SF36 – MCS (./100)	DANCE	42.27 (3.,81; 62.79)	37.53 (56.37; 63.91)	0.612	0.558
	ART	33.68 (46.66; 57.20)	34.05 (51.83; 63.45)	0.508	
Dual Task					
DT - Motor (Cup + subtraction)	DANCE	68 (56.50; 75.00)	69.50 (60.00; 73.50)	0.528	0.908
	ART	60.50 (41.13; 77.50)	68.50 (29.75; 81.50)	0.779	
DT - Cognitive (Cup + subtraction)	DANCE	13.50 (10,50; 14,50)	17.50 (13.50; 19.00)	0.107	0.728
	ART	14.25 (10.50; 21.00)	16.25 (11.25; 23.75)	0.123	
DT - Motor (Cup + WLG)	DANCE	62 (54.50; 75.50)	67 (60.00; 77.00)	0.866	0.908
	ART	65.50 (39.00;79.38)	72 (31.63; 78.88)	0.779	
DT - Cognitive (Cup + WLG)	DANCE	11 (10.00; 16.50)	15 (12.00; 19.00)	0.028*	0.908
	ART	11 (10.50; 14.00)	15.25 (11.75; 18.38)	0.017*	
DTC Motor (Cup + Subtraction)	DANCE	3.23 (2.03; 16.10)	7.69 (5.17; 17.61)	0.128	0.203
	ART	14.38 (5.17; 29.81)	16.93 (7.14; 30.16)	0.674	
DTC - Cognitive (Cup + Subtraction)	DANCE	6.67 (-11.54; 15.63)	3.13 (-2,78; 10,00)	0.735	0.183
	ART	5.63 (-6.82; 18.88)	21.15 (6.10; 31.11)	0.263	
DTC - Motor (Cup + WLG)	DANCE	7.63 (-1.64; 23.53)	8.05 (3.23; 23.86)	0.310	0.355
	ART	12.78 (10.63; 32.27)	14.83 (9.16; 30.70)	0.889	
DTC - cognitive (Cup + WLG)	DANCE	23.08 (0.00; 28.57)	-4.17 (-12.50; 9.52)	0.063°	0.203
	ART	17.19 (-16.25; 38.40)	8.86 (0.00; 17.04)	0.889	

*p<0.05
°p≈0.05
EmNSA: Erasmus modified Nottingham sensory assessment; SDMT: symbol digit modalities test; PASAT: paced auditory serial addition test; MSIS-29: 29 item Multiple sclerosis impact scale; SF36: short form 36 health survey; PCS: Physical component score; MCS: mental component score; DT: dual task; DTC: dual task cost; WLG: word list generation

Table 4:
Number of participants included in the analysis per outcome measure

Outcome measure	Included DANCE (n)	Excluded DANCE (n)	Included ART (n)	Excluded ART (n)
6MWT (distance)	7	0	7	3
DWI	7	0	7	3
6MWT (VAS)	7	0	7	3
physical MFIS	7	0	10	0
MFIS	7	0	10	0
FSS	7	0	10	0
SDMT	7	0	10	0
PASAT	6	1	10	0
CFI	6	1	10	0
MSIS-29	7	0	10	0
SF-36	7	0	10	0
MSWS	7	0	10	0
T25FTW	7	0	8	2
ABC	7	0	10	0
DGI	7	0	7	3
NHPT	7	0	10	0
EmNSA	7	0	10	0
5STS	7	0	8	2
DT	7	0	8	2
DTC	7	0	8	2

6MWT: six minute walking test; T25FW: timed 25 feet walk test; DGI: Dynamic gait Index; 5STS: five times sit-to-stand; ABC: activities-specific balance confidence scale; MSWS-12: 12 item Multiple sclerosis walking scale; NHPT: nine hole peg test; DWI: distance walking index; MFIS: modified fatigue impact scale; FSS: fatigue severity scale; VAS: visual analogue scale; CFI: cognitive fatigability index; EmNSA: Erasmus modified Nottingham sensory assessment
SDMT: symbol digit modalities test; PASAT: paced auditory serial addition test; MSIS-29: 29 item Multiple sclerosis impact scale; SF36: short form 36 health survey; PCS: Physical component score; MCS: mental component score; DT: dual task; DTC: dual task cost

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INVENTARISATIEFORMULIER WETENSCHAPPELIJKE STAGE DEEL 2

DATUM	INHOUD OVERLEG	HANDTEKENINGEN
10-13/9/18 27/8/18	pretesting participanten	Promotor: Copromotor/Begeleider: Katrien Student(e): S. Vandeynaele Student(e):
19-23/11/18	posttesting participanten	Promotor: Copromotor/Begeleider: Student(e): S. Vandeynaele Student(e): Katrien
26/11/18 3/12/18 10/12/18 17/12/18	data verwerking	Promotor: Copromotor/Begeleider: Student(e): S. Vandeynaele Student(e): Katrien
3/1/19	bespreking statistiek	Promotor: Copromotor/Begeleider: Student(e): S. Vandeynaele Student(e): Katrien
8/3/19 12/3/19 19/3/19 4/4/19	data analyse	Promotor: Copromotor/Begeleider: Student(e): Student(e): Katrien
20/5/19	feedback Resultaten	Promotor: Copromotor/Begeleider: Student(e): S. Vandeynaele Student(e):
		Promotor: Copromotor/Begeleider: Student(e): Student(e):
		Promotor: Copromotor/Begeleider: Student(e): Student(e):
		Promotor: Copromotor/Begeleider: Student(e): Student(e):
		Promotor: Copromotor/Begeleider: Student(e): Student(e):

In te vullen door de promotor(en) en eventuele copromotor aan het einde van MP2:

Naam Student(e): Sofie Caerdeynaels **Datum:** 31/5/19

Titel Masterproef: ART for MS: Effects of a 10-week multimodal dance and exercise program on fatigue, fatigability and their related factors: a controlled pilot trial

1) Geef aan in hoeverre de student(e) onderstaande competenties zelfstandig uitvoerde:
   - NVT: De student(e) leverde hierin geen bijdrage, aangezien hij/zij in een reeds lopende studie meewerkte.
   - 1: De student(e) was niet zelfstandig en sterk afhankelijk van medestudent(e) of promotor en teamleden bij de uitwerking en uitvoering.
   - 2: De student(e) had veel hulp en ondersteuning nodig bij de uitwerking en uitvoering.
   - 3: De student(e) was redelijk zelfstandig bij de uitwerking en uitvoering
   - 4: De student(e) had weinig tot geringe hulp nodig bij de uitwerking en uitvoering.
   - 5: De student(e) werkte zeer zelfstandig en had slechts zeer sporadisch hulp en bijsturing nodig van de promotor of zijn team bij de uitwerking en uitvoering.

Competenties	NVT	1	2	3	4	5
Opstelling onderzoeksvraag	●	○	○	○	○	○
Methodologische uitwerking	○	○	○	●	○	○
Data acquisitie	○	○	○	○	◕	○
Data management	○	○	○	○	○	◕
Dataverwerking/Statistiek	○	○	○	○	○	●
Rapportage	○	○	○	○	○	●

2) Niet-bindend advies: Student(e) krijgt toelating/~~geen toelating~~ (schrappen wat niet past) om bovenvermelde Wetenschappelijke stage/masterproef deel 2 te verdedigen in bovenvermelde periode. Deze eventuele toelating houdt geen garantie in dat de student geslaagd is voor dit opleidingsonderdeel.

3) Deze wetenschappelijke stage/masterproef deel 2 mag wel/~~niet (schrappen~~ wat niet past) openbaar verdedigd worden.

4) Deze wetenschappelijke stage/masterproef deel 2 mag ~~wel~~/niet (~~schrappen wat niet past~~) opgenomen worden in de bibliotheek en docserver van de UHasselt.

Datum en handtekening Student(e)	Datum en handtekening promotor(en)	Datum en handtekening Co-promotor(en)
31/5/2019	29/5/2019	31/5/2019
S. Caerdeynaels		

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INVENTARISATIEFORMULIER WETENSCHAPPELIJKE STAGE DEEL 2

DATUM	INHOUD OVERLEG	HANDTEKENINGEN
10-13/9/'18 27/8/'18	pretesting participanten	Promotor: Copromotor/Begeleider: Katrien Student(e): S. Vandeynaele Student(e):
19-23/11/'18	posttesting participanten	Promotor: Copromotor/Begeleider: Student(e): S. Vandeynaele Student(e): Katrien
26/11/'18 3/12/'18 10/12/'18 17/12/'18	data verwerking	Promotor: Copromotor/Begeleider: Student(e): S. Vandeynaele Student(e): Katrien
3/1/'19	bespreking statistiek	Promotor: Copromotor/Begeleider: Student(e): S. Vandeynaele Student(e): Katrien
8/3/'19 12/3/'19 19/3/'19 9/4/'19	data analyse	Promotor: Copromotor/Begeleider: Student(e): Student(e): Katrien
20/5/19	feedback Resultaten	Promotor: Copromotor/Begeleider: Student(e): S. Vandeynaele Student(e):
		Promotor: Copromotor/Begeleider: Student(e): Student(e):
		Promotor: Copromotor/Begeleider: Student(e): Student(e):
		Promotor: Copromotor/Begeleider: Student(e): Student(e):
		Promotor: Copromotor/Begeleider: Student(e): Student(e):

In te vullen door de promotor(en) en eventuele copromotor aan het einde van MP2:

Naam Student(e): Katrien Van den Broeck **Datum:** 31/5/'19

Titel Masterproef: Art for MS - Effects of a 10 week multimodal dance and art intervention program on fatigue, fatigability and their related factors - a controlled pilot trial

1) Geef aan in hoeverre de student(e) onderstaande competenties zelfstandig uitvoerde:
   - NVT: De student(e) leverde hierin geen bijdrage, aangezien hij/zij in een reeds lopende studie meewerkte.
   - 1: De student(e) was niet zelfstandig en sterk afhankelijk van medestudent(e) of promotor en teamleden bij de uitwerking en uitvoering.
   - 2: De student(e) had veel hulp en ondersteuning nodig bij de uitwerking en uitvoering.
   - 3: De student(e) was redelijk zelfstandig bij de uitwerking en uitvoering
   - 4: De student(e) had weinig tot geringe hulp nodig bij de uitwerking en uitvoering.
   - 5: De student(e) werkte zeer zelfstandig en had slechts zeer sporadisch hulp en bijsturing nodig van de promotor of zijn team bij de uitwerking en uitvoering.

Competenties	NVT	1	2	3	4	5
Opstelling onderzoeksvraag	●	○	○	○	○	○
Methodologische uitwerking	○	○	○	●	○	○
Data acquisitie	○	○	○	○	●	○
Data management	○	○	○	○	○	●
Dataverwerking/Statistiek	○	○	○	○	○	●
Rapportage	○	○	○	○	○	●

2) Niet-bindend advies: Student(e) krijgt toelating/~~geen toelating~~ (schrappen wat niet past) om bovenvermelde Wetenschappelijke stage/masterproef deel 2 te verdedigen in bovenvermelde periode. Deze eventuele toelating houdt geen garantie in dat de student geslaagd is voor dit opleidingsonderdeel.

3) Deze wetenschappelijke stage/masterproef deel 2 mag wel/~~niet~~ (~~schrappen~~ wat niet past) openbaar verdedigd worden.

4) Deze wetenschappelijke stage/masterproef deel 2 mag ~~wel~~/niet (~~schrappen wat niet past~~) opgenomen worden in de bibliotheek en docserver van de UHasselt.

Datum en handtekening Student(e)	Datum en handtekening promotor(en)	Datum en handtekening Co-promotor(en)
31/5/2019 Katrien	23/5/2019	31/5/2019