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Faculteit Revalidatiewetenschappen

master in de revalidatiewetenschappen en de kinesitherapie

Masterthesis

The effects of a walking to music intervention on synchronization and gait in patients with cerebellar disorders

Lene Bellinkx
Lotte Poukens

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 :
dr. Lousin MOUMDJIAN

2020
2021

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Acknowledgements

First, we would like to express our appreciation to Noorderhart Revalidatie & MS centrum for allowing us to carry out this research at their facilities during the COVID-19 pandemic. The therapists Natasja De Weerdt and Joke Lenaerts were our contact persons there and were always happy to help and answer our questions. We also wish to thank the patient, who participated in this study, for trusting us and believing in the possible positive effects of the intervention.

We also appreciate the help of the two students from master 1 (Anne Ceulemans and Febe Schuurmans) with providing the intervention in the last week and administering the post-tests. Further, we would like to thank our promotor Prof. Dr. Peter Feys for providing feedback and giving recommendations. Finally, we thank our co-promotor Dr. Lousin Moumdjian for guiding us through the whole process, from carrying out the research to writing this master thesis. She was always open to help us complete this master thesis in the last two years.

Koersel, 7/06/2021 *L.B.*

Koersel, 7/06/2021 *L.P.*

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1. Context

This master thesis is situated in the research domain of neurological rehabilitation and more precisely in the subdivision of rhythm-based interventions. As we established last year in our thesis, there has been a large, recent interest in rhythm-based interventions in neurological populations. These types of interventions seem to have a positive effect on motor functions such as gait. However, the different populations researched were mostly limited to stroke, Parkinson's Disease (PD), and Multiple Sclerosis (MS). Therefore, it would be interesting to know if it is also useful to conduct these rhythm-based interventions in patients with cerebellar disorders.

This master thesis was written according to scenario three of the guideline to present a master thesis during the COVID-19 pandemic. The master thesis should have entailed an intervention study to investigate the effects of a walking to music intervention on a treadmill including 30 patients with a neurological disease. However, due to the COVID-19 pandemic, it wasn't possible to collect data on the presupposed number of participants. Although the ethical committee of Noorderhart Revalidatie & MS centrum approved the study by December 2020, due to COVID-19 restrictions we weren't allowed to test patients until 19/03/2021. Therefore, this master thesis will present the descriptive results of one specific person. This participant with a cerebellar disorder engaged in a four-week synchronized walking to music intervention on a treadmill. Further, a global statistical plan of the intended number of participants was presented in the methodology section. This intervention study was performed under the supervision of Prof. Dr. Peter Feys (promotor) and of Dr. Lousin Moumdjian (co-promotor).

This is a duo-master thesis from Lene Bellinkx and Lotte Poukens. The first part was created last year and contained the literature review 'A qualitative analysis of rhythmic, auditory interventions while walking and their quantitative measures of cognitive function in adult neurological populations' and a protocol. The second part is an intervention study that was carried out this year at the Noorderhart Rehabilitation & MS centre. The latter is described in the following thesis.

Both students participated in the preparation of the ethical commission application. The protocol and methodology were already set in place by the research team of Dr. Lousin Moumdjian. The case subject was recruited with the help of the therapists at Noorderhart Revalidatie & MS centrum who distributed flyers of our study. Lotte was also actively involved in the process of data collection and providing the intervention. Both students had an equal contribution to the data processing and the writing process of this thesis.

2. Article

2.1. Abstract

Background: Rhythm- and music-based interventions as rehabilitation for gait and balance have been researched in multiple neurological disorders. However, the effects of these interventions on gait, balance, fatigue, and motivation have never been investigated in patients with cerebellar disorders.

Objectives: This intervention study aimed to investigate the effects of a walking to music intervention on a treadmill on synchronization, spatiotemporal gait parameters, balance, fatigue, and motivation in 30 patients with a neurological disease.

Methodology: The intervention consisted of walking to music on a treadmill twice a week. Each session lasted 20 minutes and the participants were asked to synchronize their steps to the music. Measures were taken during pre- and post-testing as well as during the intervention sessions.

Participant: The participant was a 58-year-old woman with cerebellar disorders due to meningitis in 2019.

Measurements: Primary outcome measures were: spatiotemporal gait parameters (cadence, speed, stride length, and step duration) and synchronization. Secondary outcome measures included the Dynamic Gait Index, Activities-Specific Balance Confidence scale, Six Minutes Walking Test, perceived fatigue, and motivation.

Results: The participant seemed to synchronize at her own comfortable walking pace before and after the intervention. Synchronizing at 10% above her comfortable walking pace appeared to be more difficult. However, the baseline cadence and gait speed after the intervention were higher compared to before the intervention. The participant improved in balance and perceived less fatigue after multiple sessions. Finally, she liked walking to music and adopted it in her daily life.

Conclusion: Seemingly, a walking to music intervention on a treadmill can have a positive effect on balance, perceived fatigue, and motivation. However, further research needs to verify this, provide effectiveness on spatiotemporal gait parameters and use specific synchronization measurements.

Keywords: neurological population, music-based intervention, gait, synchronization, balance, fatigue, motivation

2.2. Introduction

Cerebellar disorders are relatively common in adult populations (Salman, 2018). They can be inherited, acquired, or sporadic (Akbar & Ashizawa, 2015). Cerebellar disorders can cause different problems such as ataxia, incoordination and/or imbalance. The nature of these problems differs depending on the type, location, and severity of the lesion (Gandini et al. 2020). Deficits in the spinocerebellum can result in difficulties with poor anticipatory postural control, increased postural sway, abnormal balance responses, and automatic gait control. Changes in the cerebrocerebellum can attend to timing problems in the gait pattern and difficulties with adapting gait. Finally, deficits in the vestibulocerebellum can cause problems with balance and eye control (Kelly & Shanley, 2016). Further, gait abnormalities are also often associated with cerebellar disorders. Buckley, Mazza, and McNeill (2018) reported several changes in gait parameters among patients with cerebellar disorders, which include: reduced preferred walking speed, reduced cadence, increased variability, etc. Also, a cerebellar ataxic gait pattern due to a lack of voluntary coordination and muscle control could be present. All these problems lead to a high prevalence of falls, and therefore injuries (Marsden, 2018).

Marquer, Barbieri, and Perennou (2014) has described different rehabilitation strategies in patients with cerebellar ataxia with various etiologies. Rehabilitation programmes based on static and dynamic balance, walking, and coordination are often used (Marquer et al., 2014). Also, a home exercise program focused on static and dynamic balance training seems feasible and effective in cerebellar patients (Keller & Bastian, 2014). Other strategies that are described are multisegment coordination work (e.g. climbing exercises), the use of virtual reality tools, torso weighting, biofeedback, and gait training on a treadmill. These strategies attended to improvements in balance, gait parameters, and coordination. Winser et al. (2019) investigated Cognitive-coupled Intensive Balance Training (CIBT) and found positive effects for dual-task cost balance and the number of falls in patients with cerebellar ataxias.

The use of rhythm- and music-based interventions for rehabilitation has already been researched in neurological populations (Moumdjian, Sarkamo, Leone, Leman, & Feys, 2017). The effects of these interventions on motor function, such as improvements in spatiotemporal gait parameters have been established in stroke (Ghai & Ghai, 2019), PD (Sihvonen et al., 2017), and MS (Ghai & Ghai, 2018). As has been established, walking can be a functional and task-oriented training in persons with neurological disorders (Baird, Sandroff, & Motl, 2018; Sandroff et al., 2018). However, walking requires more than motor function. Various subdomains of cognition, such as executive function, influence a person's ability to walk (Beauchet et al., 2012). Also, there is a need to distinguish between rhythmic interventions on the treadmill and overground walking. Maggio et al. (2021) recently found that rhythmic treadmill training had more effects on walking speed and psychological factors such as perception of quality of life in patients with MS.

In cerebellar patients, the research regarding this topic is more scarce. It is known that rhythm reproduction and pitch discrimination are not affected by cerebellar disorders (Tolgyesi & Evers, 2014). Therefore, Wright et al. 2016 performed a case study where they looked into the use of metronome cueing during walking in a patient with a history of cerebellar stroke and recurrent falling. They found that spatiotemporal parameters improved in the gait trails with metronome cueing, compared to the gait trails without cueing. There was an improvement in walking speed and coefficient of variation of step time, stance time, and double support time. These results are promising and spark an interest in the use of rhythm-based strategies in gait rehabilitation of patients with cerebellar problems. Though, more research on this topic needs to be generated in further research. Also, to our knowledge, there is no literature investigating the ability of patients with cerebellar disorders to walk to music. Neither do we know if persons with cerebellar disorders can synchronize to music while walking and if this could enhance their walking performance.

The main research question that this study investigated was:
Could a four-week walking to music intervention on a treadmill alter spatiotemporal gait parameters and synchronization ability in patients with cerebellar disorders?

Additionally, secondary research questions were:

- Could a four-week walking to music intervention on a treadmill alter the clinical motor ability of patients with cerebellar disorders?
- Could a four-week walking to music intervention on a treadmill alter the perceived fatigue of patients with cerebellar disorders?
- Could a four-week walking to music intervention on a treadmill alter the motivation in patients with cerebellar disorders?

2.3. Methodology

2.3.1. Participants

2.3.1.1. Inclusion criteria

The participants who entered this intervention study met the following criteria. Cerebellar pathology was present, demonstrated by an MRI. Also, the participants had to have the ability to walk for twelve minutes as well as the ability to walk safely on a treadmill with a minimum speed of 0.8m/s.

2.3.1.2. Exclusion criteria

If the participants experienced one of the following conditions, they were excluded from the intervention study. Severe cognitive impairment, deafness, or amusia that ensured that the participants wouldn't have been able to understand or perform the intervention.

2.3.1.3. Descriptive characteristics

General information about the participants included personal information such as sex, date of birth, length, and weight. Also, type, nature, and duration of schooling were asked. Information related to the cerebellar problem like the date of the first symptom, date of diagnosis, and medication was also described. Finally, information about the musical history of the participants was also included.

2.3.2. Procedure

2.3.2.1. Recruitment

The participants were recruited through the therapists of the rehabilitation centre, Noorderhart Rehabilitation & MS centre. Flyers that contained information about the study were provided to the therapists.

2.3.2.2. Intervention

In total, the participants engaged in a four-week walking to music intervention on a treadmill. A week before and after the intervention, the participants underwent pre- and post-testing. These consisted of a two-hour session, implementing multiple periods of rest, to collect the different data. In the intervention itself, the participants performed 20 minutes sessions (10 min-break-10 min), two times a week at Noorderhart Rehabilitation & MS centre. See Figure 1 for an overview of the organization of the study design. The full intervention session was performed before any other type of usual rehabilitation that day. The participants underwent a familiarisation task; based on previous studies (Moumdjian, Moens, Maes, Van Geel, et al., 2019; Moumdjian, Moens, Maes, Van Nieuwenhoven, et al., 2019), the song 'Sanctum' by the artist 'Shades of the Abyss' was used to instruct the participants to synchronize by stepping to the beat. They were then equipped with two watch-like sensors attached at the ankles (NGIMU, UK). They were asked to undergo the intervention of walking on the treadmill (Biodex, USA) while synchronizing their steps to the music they heard. The training included walking to music at different tempi. The music used in the intervention was fitted to the participants' baseline cadence. A personalized music database was used containing songs that ranged from 70 to 140 beats per minute (BPM) (Buhmann J & M., 2016). These were selected randomly based on the participants' initial cadence. The provided music was divided into six different genres: disco, pop-rock, pop, instrumental, soft pop, and variety. The participants could choose a different genre each week. The gait speed of each participant was established in the first session. To stay as standardized as possible the communication with the researcher providing the intervention was left to a minimum. Only in case of questions help was given by the researcher, who was mostly there for supervision. The testing and intervention sessions were always individually guided. More details regarding the organization of the testing and intervention sessions can be found in Appendix 1.

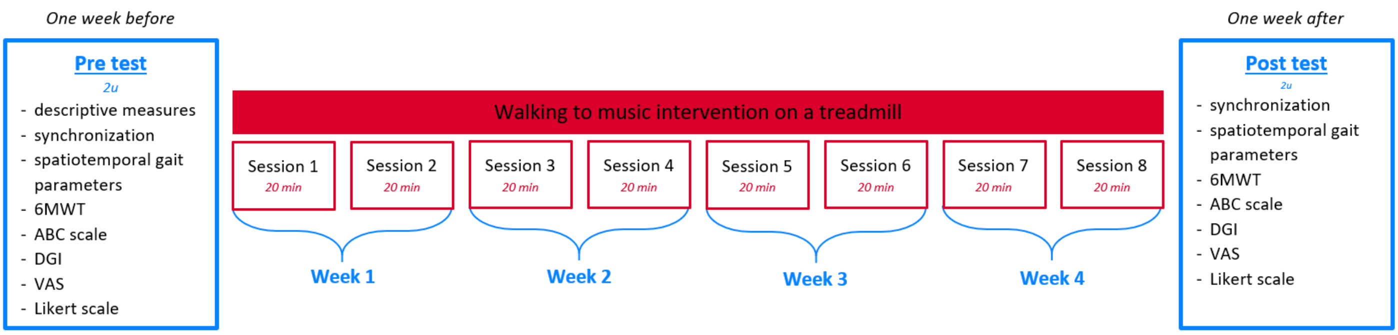

Figure 1. Study design

2.3.2.3. COVID-19 precautionary measures

Because this study took place in the COVID-19 pandemic, extra precautions were taken to create the safest possible environment. Face masks were worn at all times both by the researcher and the participants. Hygienic measures were respected, the researcher, as well as the participants, were asked to disinfect their hands when entering the MS centres, as well as prior to entering the allocated location where the research took place.

The researcher ensured to have disinfected all materials which were used by the participants. This included the sensors, the treadmill, the table, and the chair where the participants were asked to rest. The researcher ensured that the participants avoided touching materials themselves. There was a disinfected pen for the participants to use (sharing of pens between the researcher and the participants did not occur). Apart from having to strap the sensors on the participants (which was on the feet), the researcher remained the distance of 1.5m from the participants at all times, except when a risk of fall was detected.

In case the researcher or the participants experienced one of the following symptoms: cough, respiratory problems, fever, aches and pains, loss of sense of smell or taste, or diarrhoea the intervention session was cancelled. Similarly, if the researcher or participants had had a high-risk contact, the session was also cancelled.

2.3.3. Outcome Measures

Below, all outcome measures used in this study will be described. First, the descriptive measures are mentioned, then primary outcome measures, and lastly secondary outcome measures.

2.3.3.1. Descriptive measures

The descriptive measures were administered to get an idea of the functioning of the patients at the beginning of the intervention. These are dived into different categories: motor function, cognitive function, beat perception, and questionnaires.

Motor function

Timed 25-Foot Walk Test (T25FWT)

The participants were asked to walk 25 foot as quickly as possible, without running. The time was measured by the researcher. In this test, a cut-off value of 20% is considered meaningful (Bosma et al., 2010).

Motricity Index (MI)

The MI measured the maximal isometric strength the participants could produce. Normally, both arms and legs could be tested, but in this study, only the force of both legs was assessed. Therefore, the following muscle groups were tested: hip flexors, knee extensors, and ankle dorsiflexors. Each muscle group could get a score between 0 and 33. A higher score corresponds with higher force production. When the participants got a full score on each group, one point was added up to come to 100 for the total score. The MI has good reliability and validity in patients after stroke (Gor-Garcia-Fogeda et al., 2014).

Modified Ashworth Scale (MAS)

The MAS was a scale to test the amount of spasticity in various muscle groups. The scoring ranged from 0 to 4. If no increase in muscle tone was found, a score of 0 was given. When affected parts are rigid both in flexion and extension, a score of 4 was assessed. For this study following muscle groups were evaluated: Mm. Hamstrings, Mm. Triceps Surae, Mm. Quadriceps.

Timed Up and Go (TUG)

The TUG was a measurement to test gait and balance, which then could indicate a possible fall risk. The starting position of the participants was sitting on a chair (arm support was allowed). When the researcher had given a signal, the participants stood up from the chair, walked 3 meters, turned, walked back, and took a seat again. The researcher clocked the time from the given signal until the participants are seated in the chair again. The TUG has shown to have good reliability and moderate validity in ataxic patients secondary to MS (Winser et al., 2017). There are no specific cut-off values for cerebellar patients. However, community-dwelling adults have a cut-off value of 13,5 seconds (Shumway-Cook, 2000).

Scale for Assessment and Rating of Ataxia (SARA)

This was a rating scale that assessed 8 different dimensions that ataxia could affect (gait, stance, sitting, speech, finger chase, nose-finger, fast alternating movements, and heel-shin slide). Both the right and left sides were assessed, to finalise a mean score of both sides per item were measured. In the SARA a maximum score of 40 could be achieved, but a lower total score indicated fewer problems with ataxia. A score of 5,5 or less indicated a minimal dependence in activities of daily living (B. R. Kim et al., 2011).

Cognitive function

Paced Auditory Serial Addition Test (PASAT)

The PASAT was a test to assess sustained attention and information processing speed. In this test, the instructor presented a different single digit every three seconds. The participants must add every new digit to the previous one. The test had good test-occasion and test-retest reliability in people with MS (Sonder, Burggraaff, Knol, Polman, & Uitdehaag, 2014). The PASAT has been reported to be a sensitive measure of cognitive impairment. Further, it was reported that people with multiple sclerosis perform more poorly than controls on this test (Rogers & Panegyres, 2007).

Symbol Digit Modalities Test (SDMT)

In performing the SDMT, the participants got 90 seconds to link the correct number to the correct geometric figure. The answer could be given in writing or oral. According (Benedict et al., 2017), the SDMT was a valid measure of cognitive processing speed or efficiency. For reliability, the SDMT has shown a sensitivity of 74.2% and specificity of 76.9% in predicting cognitive impairment in MS patients (Rogers & Panegyres, 2007).

Beat perception

Montreal Battery of Evaluation of Amusia (MBEA)

In this study, the subdomains rhythm and interval of the short MBEA were used to examine possible amusia in the participants. This short version of the MBEA consisted of fifteen pairs of melodies in which the participants had to define if they are the same or different from each other (Nunes-Silva & Haase, 2012).

Questionnaires

Modified Fatigue Impact Scale (MFIS)

MFIS is a self-report questionnaire that indicated the impact of the patients' fatigue in daily life. The total MFIS score ranged from 0 to 84. The MFIS could also be divided into 3 subscales: psychosocial, physical, cognitive. However, the cut-off value was based on the total score and is captured at 38 (Lianza, 2007).

Dual tasks questionnaire

This self-report questionnaire was reported in (Evans, Greenfield, Wilson, & Bateman, 2009). It was a 10-item questionnaire that questions the possible difficulties while performing dual tasks. The participants could range their answers between 'very often' and 'never'.

Hospital Anxiety and Depression Scale (HADS)

The HADS was a self-report questionnaire that questioned the participants' fear and depression independent of their physical condition. Both fear and depression had seven items that asked about the participants' feelings during the previous week. Each item was ordinal scaled from 0 to 3. So, both depression and fear received separately a maximal total score of 21. A scoring of 8-10 indicated a possible depression and/or anxiety disorder. A scoring of 11-21 indicated a probable depression and/or anxiety disorder (Hermann, 1997).

Credibility and expectations questionnaire

This questionnaire contained two parts that determined how the participants felt about the intervention. The first part considered the intervention in general, the second part asked about the intervention and possible success for the participants themselves (Kazdin, A. E. 1979). Further, this questionnaire has shown to have good validity and reliability (Devilly, 2000).

2.3.3.2. Primary outcome measures

The following section discusses the primary outcome measure. This contains the walking paradigm, which is divided into a synchronization measure and spatiotemporal gait parameters.

<u>Walking paradigm</u>

In both synchronization and spatiotemporal gait parameters, the data collection was recorded by APDM sensors (OPAL, USA).

Synchronization

For the walking task, the participants received a headphone and D-Jogger (Moens et al., 2014) equipment to walk. The participants were asked to synchronize their walking to the music. The participant performed five conditions: baseline, 'high' 0%, 'high' 10%, 'low' 0% and 'low' 10%. The meaning of 'high' or 'low' in this context indicated the beat accentuation in the played song. Therefore, 'high' 0% means that the participants walked at their comfortable pace to a song with an accentuated beat. Contrary, 'low' 10% indicated that the participants walked at a pace 10% above their comfortable pace, and the beats to place their steps on were less accentuated. Before starting the various conditions, the participants walked without any music for one minute. Based on the number of steps the participants placed in that minute, the songs were selected for the correct BPM. Each condition was executed for three minutes. In between the conditions, the participants were able to rest. The order of the different conditions was randomized by a digital randomization program. The outcome measure of the synchronization was tempo matching (steps/min), in which the cadence was subtracted from the BPM.

Spatiotemporal gait parameters

Following measurements were recorded for data collection: cadence, speed, step duration, and stride length.

2.3.3.3. Secondary outcome measures

This part elaborates on the clinical motor assessments, fatigue, and motivation as secondary outcome measures.

6 Minute Walking Test (6MWT)

In this test, the participants needed to walk as fast as possible, but safely for six minutes. After the six-minute walk, the instructor measured the established total number of meters. It's often used in practice to evaluate gait analysis, walking speed, and capacity. This test had a good validity in neurological populations and excellent reliability in cerebellar ataxia (Milne et al., 2018; Tyson, 2009).

Dynamic Gait Index (DGI)

The DGI was an eight-item test that was developed to assess the risk of falling, mostly in older adults. This ordinal scale had a ranging from 0 to 3. The lowest level of function is indicated with 0, the highest level of function with 3. Therefore, the maximum total score was 24. When the participants scored below 19/24 on this test, a higher risk of falling was present (Shumway-Cook & Woollacott, 1995).

Activities-Specific Balance Confidence Scale (ABC)

The ABC scale was a 16-item self-report questionnaire. Each item represented a daily activity. The participants reported, ranging from 0 to 100, how confident they were in executing every activity without losing balance or falling. A higher score on the ABC scale correlated with more confidence to safely perform the activity.

Perceived fatigue: Visual Analogue Scale (VAS)

Before and after each intervention session, the participants were asked to rate their perceived cognitive and physical fatigue. This was recorded by the VAS. This was a numeric rating scale ranging from 0 to 10. When indicating a 0 score, the participants felt no fatigue. When indicating a 10 score, the participant perceived the worst fatigue possible.

Motivation: Likert Scale

Before and after each intervention session, the participants were asked how large their motivation for the intervention was. This was done by using the Likert Scale, with ranging scores from 1 to 5. When no motivation was present, a score of one was given. However, if the participants were fully motivated, a score of 5 was given.

2.3.4. Equipment

2.3.4.1. During the pre- and post-testing

<u>D-Jogger</u>

D-jogger (Moens et al., 2014) was used, which consisted of headphones, sensors, and a laptop with custom-made software. For the walking paradigm, the NGIMU and ADPM sensors were strapped to the ankles and feet. The participants walked with a wireless headphone device. The music presented during the pre-and post-testing was standardized and different from those that was used in the intervention session.

Figure 2a. D-jogger

Figure 2b. Frequency regulator

Figure 2c. Internet modem

<u>APDM sensors</u>

These were used in the pre- and post-testing of the walking paradigm. Participants were equipped with two portable APDM sensors (OPAL, USA), which were strapped around the forefeet, to measure spatiotemporal gait parameters (Washabaugh, Kalyanaraman, Adamczyk, Claflin, & Krishnan, 2017) as in previous research (Moumdjian, Moens, Maes, Van Geel, et al., 2019; Moumdjian, Moens, Maes, Van Nieuwenhoven, et al., 2019; Moumdjian, Moens, Vanzeir, et al., 2019).

Figure 2d. APDM sensors

NGIMU sensors

These watch-like sensors were used during the walking paradigm to conduct the data on gait parameters (X-IO technologies, UK).

Figure 2e. NGIMU sensors

2.3.4.2. During the intervention

BIODEX gait trainer 3

This was a treadmill consisting of a tablet and a speaker. Different music could be played through the speakers and the BPM of these songs could be adapted according to the participants' needs through the tablet. (Biodex, USA)

Figure 2f. BIODEX gait trainer 3

Figure 2g.Tablet and speaker

NGIMU sensors

These watch-like sensors were used in each intervention session to conduct the data on gait parameters (X-IO technologies, UK).

Figure 2e. NGIMU sensors

Laptop

The laptop ran on a specific internal network. Further, it consisted of a custom-made software program to log the data. Before it was possible to start capturing the data, the following information had to be filled in: participants' ID, number of the session, option synchronization, and connection with the left and right NGIMU sensors. Also, the musical numbers used in the session could be uploaded to the program. However, when the song changed on the treadmill, the researcher had to switch it manually in the program.

Figure 2c. Internet modem

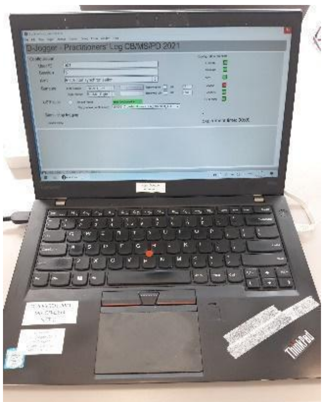

Figure 2h. Laptop with software

2.3.5. Data-analysis

The foregoing protocol would have been applied to 30 persons with a neurological disease prior to the COVID-19 restrictions. The only additional difference to the protocol would have been that there were three arms to the intervention e.g. synchronized walking to music, not synchronized walking to music, and walking without music. Therefore, the participants would have been randomly assigned to one of the three arms.

The following statistical analysis was planned in case of the protocol before the COVID-19 restrictions. The descriptive data would have been scanned for normality by the Shapiro-Wilk test. If the data was normally distributed, it would be analysed by a t-test. If the data wasn't normally distributed, it would be analysed by the Wilcoxon signed rank test. For the primary and secondary outcome measures, analysis of variance (ANOVA) would have been performed. Therefore, the following assumptions were ascertained before each analysis: normality of data by checking the residual plots, homoscedasticity by completing the Brown-Forsythe test, and independence of data by the study design. A 2x3 ANOVA model was conducted with time (pre- and post-test) and study arm (synchronization, no synchronization, no music) as independent variables on all primary and secondary outcome measures except for synchronization. The latter was analysed through a 2x3x4 ANOVA model with time (pre- and post-test), study arm (synchronization, no synchronization, no music), and audio (0% low, 0% high, 10% low, 10% high) as independent variables. In case of interactions being present, a multiple comparison Tukey's test would have been used as a post-hoc test. The level of significance would have been fixed at $p < 0.05$. All statistical analysis would have been conducted through software program SAS JMP Pro 15.2 (SAS, USA).
However, due to the COVID-19 pandemic, a restricted application of the protocol was performed. There was only one participant and she had a cerebellar disorder. The participant was placed in the first intervention arm e.g. synchronized walking to music. Because of the case study format, the normality of data couldn't be checked. Therefore, it was not possible to perform an adequate statistical analysis on the obtained data. Differences within pre-or post-testing and/or intervention sessions were described but not statically analysed. In order to provide some clinical relevance, the researchers weighed the differences between pre- and post-testing against the minimal detectable change (MDC).

2.4. Results

Because of the COVID-19 pandemic, the complete study, as it was intended, couldn't be performed. Instead, the researchers presented a section of the larger study as a case study. Therefore, the data-analysis of the original, larger study design was described above but not executed in the results section of this article. The results of the case study were described without statistical analysis.

2.4.1. Participant

The participant that took part in this case study was a 58-year-old woman with cerebellar problems due to meningitis that she went through in 2019. She was rehabilitating three times a week in Noorderhart Rehabilitation & MS centre in Pelt. Her descriptive characteristics can be found in table 1. Information about the music used during the intervention can be found in Appendix 2.

Table 1
Descriptive characteristics patient

Age	58 year
Gender	female
Weight	60 kg
Height	165 cm
Education	master's degree
Disease information	meningitis
Year diagnosis	2019
Music-related experience	none
Physical activity	a lot of walking no driving anymore
Work	stopped (2019)

2.4.2. Descriptive measures

To form a holistic image of the participant, multiple descriptive measures were taken including motor function, cognitive function, beat perception, and self-report questionnaires. The results for each test can be found in table 2. Regarding motor function, she had maximal isometric strength on both sides and no spasticity. In the assessment of the SARA, the participant scored lower than 5,5 indicating minimal dependence in activities of daily living (B. R. Kim et al., 2011). No severe impairment in beat perception was measured by the Montreal Battery of Evaluation of Amusia. The participant scored above the cut-off scores of the PASAT (≤35) and SDMT (≤49), indicating no cognitive impairment to be present (Lopez-Gongora, Querol, & Escartin, 2015). However, according to the dual-task questionnaire, she did experience difficulty performing multiple tasks at the same time. The other self-report questionnaires indicated no presence of severe anxiety or depression. On the other hand, she reported a scoring above the cut-off for the MFIS (>38), indicating general fatigue being very present in her life (Lianza, 2007). When looking at the credibility and expectations questionnaire (CEQ) we could conclude that the participant had a positive outlook on the possible impact of this intervention in general.

Table 2
Descriptive measures

	Outcome measures	Subscores	Baseline
Motor function	T25FWT (sec)		3.54
	MI (0-33)	*dorsiflexors (L + R)*	33
		knee extensors (L + R)	33
		hip flexors (L + R)	33
	MAS (0-4)	*hamstrings (L + R)*	0
		triceps surae (L + R)	0
		quadriceps (L + R)	0
	TUG (sec)	*mean*	8.38
	SARA (0-40)		2.5
Cognitive function	PASAT (0-60)		37
	SDMT (0-110)		52
Beat perception	MBEA (0-15)	*interval*	10
		rhythm	11
Questionnaires	MFIS (total score: 0-84)	*total score*	52
		physical subscale	23
		cognitive subscale	26
		psychosocial subscale	3
	dual-task questionnaire (0-40)		27
	HADS (total score: 0-42)	*total score*	20
		anxiety	15
		depression	5

HADS: Hospital Anxiety and Depression Scale; L: left; m: meter; MAS: Modified Ashworth Scale; MBEA: Montreal Battery of Evaluation of Amusia; MFIS: Modified Fatigue Impact Scale; MI: Motricity Index; PASAT: Paced Auditory Serial Addition Test; R: right; SARA: Scale for Assessment and Rating of Ataxia; SDMT: Symbols Digit Modalities Test; sec: seconds; T25FWT: Timed 25-Foot Walking Test; TUG: Timed Up and Go

2.4.3. Primary outcome measures

2.4.3.1. Walking paradigm – synchronization

In order to find out if the participant matched her tempo to the musical beat, her cadence in each condition was subtracted from the BPM. In the 'participants' comfortable walking pace' condition before the intervention, the participant stayed close to complete synchronization (table 3). In 'high' beat accentuation her cadence was 1.335 steps/min faster than the presented BPM. In 'low' beat accentuation her cadence was 0.665 steps/min faster than the presented BPM. If the musical beats were raised 10% above her comfortable walking pace, her cadence didn't reach the BPM in both 'high' and 'low' beat accentuation (4.690 and 4.630 steps/min below BPM).

After the intervention, the participant started at a higher beat frequency compared to before the intervention. In the participants' comfortable walking pace, full synchronization was closely approximated in both beat accentuation conditions. In the 'high' condition her cadence was 0.170 steps/min slower than BPM. In the 'low' condition, this was 0.450 steps/min slower. When the BPM was raised by 10%, less synchronization was present. In the 'high' beat accentuation, her cadence was 13.495 steps/min slower compared to the BPM. In the 'low' beat clarity it was even 13.590 steps/min slower.

2.4.3.2. Walking paradigm – spatiotemporal gait parameters

In the description of the spatiotemporal gait parameters, average numbers of the left and right leg were used as measures. A summary of all spatiotemporal gait parameters can be found in table 3.

<u>Cadence</u>

The participant reached in the pre-testing an average baseline cadence of 114.125 steps/min (figure 3a). At the participants' comfortable walking pace with 'high' beat accentuation, the participant walked 1.335 steps/min faster than the baseline (+1.17%). At 'low' beat accentuation she walked 0.665 steps/min faster than baseline (+0.58%). When increasing her comfortable walking pace by 10%, her cadence during the 'high' beat accentuation progressed to 6.725 steps/min compared to baseline (+5.89%). During 'low' beat accentuation, her cadence increased by 6.785 steps/min compared to baseline (+5.95%).

In the post-testing, the participants' average cadence at baseline was 119.750 steps/min, showing an increase of 5.625 steps/min compared to the pre-testing. The participants' comfortable walking pace at post-testing with 'high' beat accentuation showed a difference of -0.170 steps/min compared to the baseline (-0.14%). At ‘low’ beat accentuation a difference of -0.450 was shown (-0.38%). When elevating the pace with 10%, at ‘high’ beat accentuation there was a cadence difference of -1.520 present compared to baseline (-1.27%). At the same pace with ‘low’ beat accentuation a difference of -1.615 to baseline was found (-1.35%).

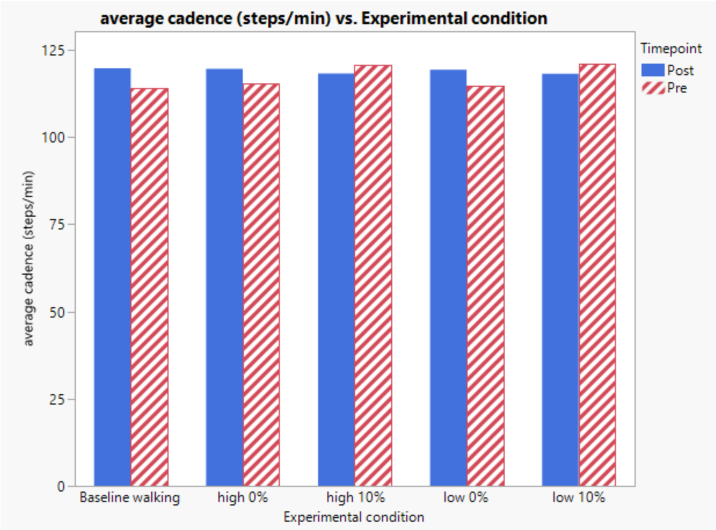

Figure 3a. Average cadence (steps/min) in the 5 walking conditions

Gait speed

The average gait speed at baseline during the pre-testing was 0.965 m/sec (figure 3b). At the participants’ comfortable walking pace with ‘high’ beat accentuation, an increase of 0.080 m/sec was present compared to baseline (+8.29%). At ‘low’ beat accentuation, the raise was 0.0350 m/sec compared to baseline (+3.63%). When elevating the participants’ comfortable walking pace by 10%, the gait speed during 'high' beat accentuation also increased by 0.035 m/sec (+3.63%). At 'low' beat accentuation, this was an increase with 0.075 m/sec compared to baseline (+7.77%).

In post-testing, the average gait speed was 1.135 m/sec. That’s 0.170 m/sec faster than during pre-testing. At the participants’ comfortable walking pace with a ‘high’ beat accentuation, she walked 0.080 m/sec faster compared to baseline (+8.29%). At ‘low’ beat accentuation an increase of 0.040 m/sec was found compared to baseline (+4.15%). When pacing at 10% above her comfortable walking space, the ‘high’ beat accentuation ensures a 0.005 m/sec increase compared to baseline (+0.52%). At ‘low’ beat accentuation, there was a diminishment of 0.025 m/sec in gait speed compared to baseline (-2.2%).

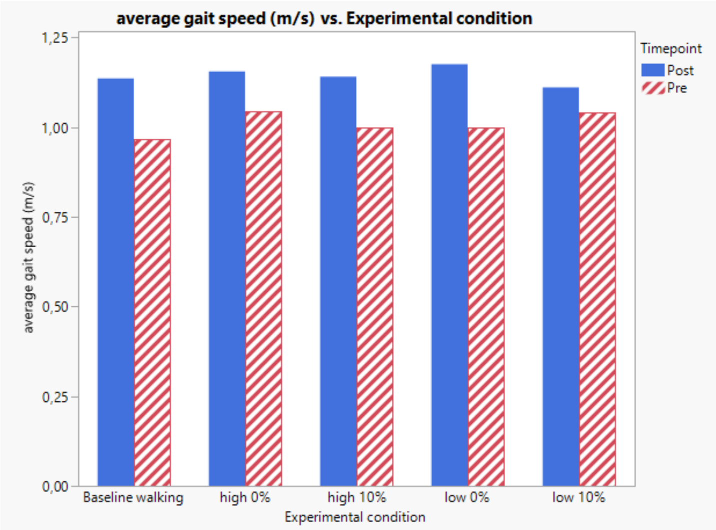

Figure 3b. Average gait speed (m/sec) in the 5 walking conditions

<u>Step duration</u>

The average baseline step duration during the pre-testing was 0.530 sec (figure 3c). When walking at the participants' comfortable walking pace with a 'high' beat accentuation, a difference of -0.015 sec was measured compared to baseline (-2.83%). With a 'low' beat accentuation this difference was -0.010 (-1.89%). Raising the pace by 10%, the step duration, using either 'high' or 'low' beat accentuation, was reduced by 0.035 sec compared to baseline (-6.6%).

At post-testing, the baseline step duration was 0.505 sec, which is 0.025 slower than during the pre-testing. At the participants' comfortable walking pace with a 'high' beat accentuation, there was a step duration of 0.005 sec smaller than baseline (-0.99%). There was no difference in step duration between 'low' beat accentuation and baseline at the participants' comfortable walking pace. When increasing the pace with 10%, both in the 'high' as 'low' beat accentuation a difference of 0.005 sec was found compared to baseline (+0.99%).

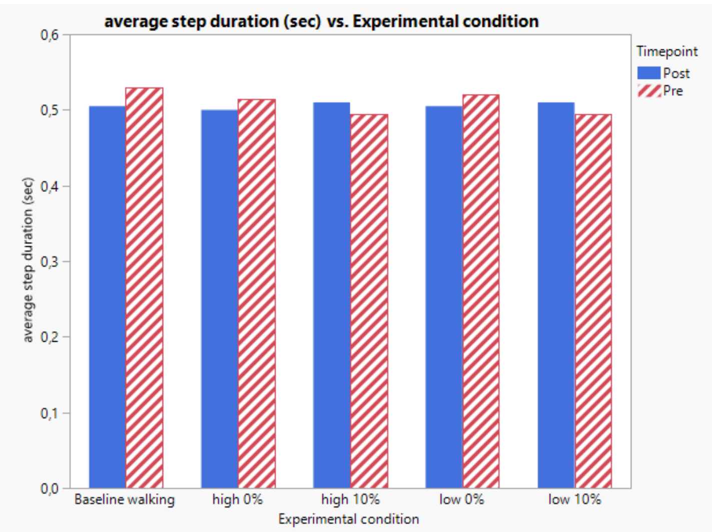

Figure 3c. Average step duration (sec) in the 5 walking conditions

Stride length

The average stride length during the pre-testing was 1.010 m (figure 3d). When walking to music at the participants' comfortable walking pace, an increase of 0.080 m was recorded at 'high' beat accentuation compared to baseline (+7.92%). At 'low' beat accentuation this increase was 0.040 m (+3.96%). When walking to music 10% higher than the participants' normal pace, the stride length during 'high' beat accentuation was 0.020 m less compared to baseline (-1.98%). However at 'low' beat accentuation, there was an increase of the same amount.

At the post-testing, the average stride length was 1.135 m, which was an increase of 0.125 m compared to the pre-testing. Furthermore, the stride length during post-testing at the participants' comfortable walking pace using 'high' beat accentuation was 0.025 m larger than baseline (+2.2%). At the same pace but with 'low' beat accentuation the difference was 0.045 m compared to baseline (+3.96%). When raising the music pace with 10%, at 'high' beat accentuation a difference of 0.015 m was found compared to baseline (+1.32%). For the 'low' beat accentuation condition, this was a small decrease of 0.005 m compared to baseline (-0.44%).

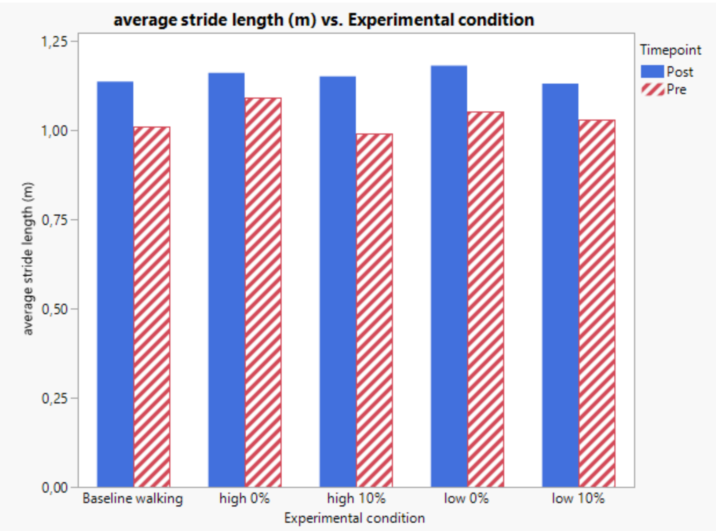

Figure 3d. Average stride length (m) in the 5 walking conditions

Table 3
Results of primary outcome measures

Outcome measures		Pre					Post				
		baseline	0% high	0% low	10% high	10% low	baseline	0% high	0% low	10% high	10% low
Spatiotemporal gait parameters	Cadence (steps/min)	114.125	115.460	114.790	120.850	120.910	119.750	119.580	119.185	118.230	118.135
	Gait speed (m/sec)	0.965	1.045	1	1	1.040	1.135	1.155	1.175	1.140	1.110
	Step duration (sec)	0.530	0.515	0.520	0.495	0.495	0.505	0.500	0.505	0.510	0.510
	Stride length (m)	1.010	1.090	1.050	0.990	1.030	1.135	1.160	1.180	1.150	1.130
Synchronization	Tempo matching* (steps/min)		-1.335	-0.665	4.690	4.630		0.170	0.450	13.495	13.590

**beats per minute - steps per minute; m: meter; min: minute; sec: seconds*

2.4.4. Secondary outcome measures

A summary of the participants' clinical performance can be found in table 4.

2.4.4.1. Walking and balance

Six-Minutes Walking Test (6MWT)

In the secondary outcome measures, the 6MWT before the intervention was 591.02 meters. After the intervention, the accomplished distance was 592.32 (table 4). The difference is clearly below the minimal detectable change (MDC stroke: 34,4 m) (Eng, Dawson, & Chu, 2004).

Dynamic Gait Index (DGI)

The participant scored 19/24 before the intervention. After the intervention, a scoring of 21/24 was measured. The participant performed both testings without any assistive device. Depending on the source, an increase of 2 points could be either above or below the MCD (Alghadir, Al-Eisa, Anwer, & Sarkar, 2018; Cattaneo et al., 2007; Huang Sheau-Ling & Chin-Hsien Lin, 2011).

Activities-Specific Balance Confidence Scale (ABC)

Before the intervention, the participant had overall confidence of not falling of 59.38% in the questionnaires proposed activities. After the intervention, she perceived confidence of 70% in the same activities. This was an increase of 10.62% in subjective balance performance. This was close to the MDC that is measured in PD (11.12%) (Dal Bello-Haas, Klassen, Sheppard, & Metcalfe, 2011).

2.4.4.2. Perceived fatigue

Physical fatigue

In four of the eight sessions, the participant experienced physical fatigue lower post-session compared to pre-session. This was each time a lowering of one point in the VAS-score. In three sessions she experienced no difference in physical fatigue. Only in session three, she perceived a higher physical fatigue post-session compared to pre-session (one point raise on the VAS-score).

Cognitive fatigue

The cognitive fatigue was a point lower in four of the eight sessions after the session compared to before the session. The decline in cognitive and physical fatigue after the session occurred in the same sessions (2, 4, 5 and 8). In two sessions the participant felt more cognitively fatigued after the session compared to before. Also, in two sessions there was no difference in perceived cognitive fatigue before and after the session.

2.4.4.3. Motivation

The participant was very motivated to participate in each session. In six of the eight sessions, she started already with a maximum score on the Likert scale and the maximum score maintained during the session. In two sessions the participant scored a four out of five before the session but was maximally motivated during the session.

Table 4

Results secondary outcome measures

	Outcome measures	Pre								Post							
Walking and balance	6MWT (m)	591,02								592.32							
	DGI (0-24)	19								21							
	ABC (%)	59.38								70							
	Outcome measures	S1		S2		S3		S4		S5		S6		S7		S8	
		before	after	before	after	before	after	before	after	before	after	before	after	before	after	before	after
Perceived fatigue (VAS: 0-10)	cognitive fatigue	2	3	5	4	1	2	7	6	4	3	3	3	2	2	4	3
	physical fatigue	2	2	5	4	1	2	7	6	4	3	3	3	2	2	4	3
Motivation (Likert Scale: 1-5)	Motivation	5	5	5	5	5	5	4	5	5	5	4	5	5	5	5	5

6MWT: 6 Minute Walking Test; ABC: Activities-Specific Balance Confidence scale; after: after the intervention session; before: before the intervention session; DGI: Dynamic Gait Index; m: metre; S: session; VAS: Visual Analogue Scale

2.5. Discussion

This thesis wanted to investigate the effectiveness of a walking to music intervention on a treadmill on synchronization, motor ability, fatigue, and motivation in patients with cerebellar disorders. When looking at the ability of the participant to synchronize, it seems she was more capable to do this at her comfortable walking pace. This was the case before as well as after the intervention. However, she increased her baseline cadence by 5.625 steps/min after the intervention compared to with before the intervention. After the intervention, she was able to synchronize close to her comfortable walking pace, but couldn't synchronize when the post-baseline was raised by 10%. This indicated that the participant probably has reached the ceiling of her capacities when walking at a cadence of around 120 steps/min (figure 3a). Gait speed and stride length presented similar results where there was a remarkable difference in gait speed during the walking paradigm of the pre-and post-testing (figure 3b and 3d). However, no real conclusions could be made for synchronization because specific outcome measures such as relative Phase Angle (rPA: timing of footfall relative to the beat) and Resultant Vector Length (RVL: ability of the rPA to stay stable over time) weren't present in this thesis due to limited time (Moumdjian, Moens, Maes, Van Geel, et al., 2019). A higher baseline gait speed was present post-intervention, but this speed stayed approximately the same in the different conditions (figure 3b). The higher baseline speed post-intervention is in contrast with the results on the 6MWT, where no changes were found in walking distance (Eng et al., 2004). Various research in other neurological disorders has found improvement of endurance and walking speed measured by 6MWT when walking to music (Chaiwanichsiri, 2011; Harro et al., 2014). To our knowledge, this hasn't been researched in cerebellar disorders. The researchers in this study were hypothesizing that would have been the case considering the fact that she received additional walking training on top of her usual physical therapy. But, the participants' gait speed was already 5,91 km/h on the 6MWT before starting the intervention without any walking fatigability. This could indicate that she was again performing at the maximum of her ability and no further improvement was possible.

Further, it was seen in multiple sessions that the participant perceived lower physical and/or cognitive fatigue levels after walking to music. This shows that the intervention was tolerated well by the participant. One explanation for this could be that she really liked the songs. Even though she wasn't familiar with the songs in some sessions, she did report enjoying them (Appendix 2). Earlier, Park, Hass, Patel, and Janelle (2020) has shown that the emotional component of music affects gait parameters such as velocity and arm swing comparing pleasant music to neutral or even unpleasant

music. Also, previous research has shown that the genre of music can alter gait in patients with PD. For example, classical music would reduce walking speed and trunk tilting. Contrary, the range of pelvic obliquity movements can be increased by rock music (De Bartolo et al., 2020). Each week the participant chose a different genre of music to walk on. This could affect her performance to synchronize or her gait parameters. Further, the complexity of the chords presented in the different songs could also play a role in for example gait parameters and synchronization. S. J. Kim, Yoo, Shin, and Cho (2020) reported that complex chords can alter the gait pattern, such as maximal ankle plantar flexion in the preswing phase, compared to simple chords. Therefore, clarity of beat perception was taken into account in this study. The participant walked both at a 'high' or 'low' accentuation of beat perception during the pre-and post-testing. However, in this study, the participant doesn't seem to alter her gait pattern depending on the clarity of the beats. Possibly, because the participants' beat perception at the start wasn't impaired (assessed by the MBEA), she had no difficulty navigating the beats either 'high' or 'low'.
Additionally, the participant was very motivated to walk on music (table 4). In two sessions she was even more motivated after the intervention than before. These findings were in line with earlier reported research by (Moumdjian, Moens, Maes, Van Geel, et al., 2019), which has shown walking to music to be more motivational compared to metronome sounds or no sound at all. Additionally, this participant had such a positive experience of walking to music, that she implemented walking to music in her daily life. Furthermore, she indicated lower anxiety and depression levels beyond minimal detectable change after the complete intervention. Burt et al. (2020) has found similar results with a music-contingent gait training on the Geriatric Depression Scale and Beck Anxiety Inventory in patients with PD. When looking even broader at the quality of life previous music-based movement therapy has shown a trend towards improvement but no significant difference (Zhou, Zhou, Wei, Luan, & Li, 2021).

Considering the fact that the participant experienced a fear of falling in daily activities (ABC-questionnaire) and her DGI was borderline to an enlarged risk of falling, the researchers were interested to see if this walking to music intervention on a treadmill would benefit the participants' balance. She improved both objectively in the DGI and subjectively reported by the ABC-questionnaire after the intervention. Unfortunately, the MDC in cerebellar patients for the DGI had not been determined in literature. Therefore, compared to PD (MDC: 2,3), MS (MDC: 5,54), and stroke (MDC: 1,9), it's possible that this improvement fell within the limits of a measurement error (Alghadir et al., 2018; Cattaneo et al, 2007; Huang Sheau-Ling & Chin-Hsien Lin, 2011). For the ABC-questionnaire, the MDC was fixed on 11,12%. However, that was also in a different population (Dal Bello-Haas et al., 2011). On that account, there was a possibility that this participant both objectively and subjectively had improved in balance, as we don't know the MDC in cerebellar patients. The important note here was that the participant perceived more confidence in her balance than before the intervention. There was a possibility that the improvement in balance due to music-based interventions was dependent on the population. In PD multiple researchers have found significant improvements in objective (BBS, Mini-Balance Evaluation Systems Test) and subjective (ABC-questionnaire) measurements (Calabro et al., 2019; de Dreu, van der Wilk, Poppe, Kwakkel, & van Wegen, 2012; Murgia et al., 2018; Zhou et al., 2021). However, researching these interventions in (chronic) stroke the evidence was more unclear. Some studies have shown that music-based interventions are not superior to conventional therapy or rehabilitation without music to improve balance (Elsner, Scholer, Kon, & Mehrholz, 2020; Gonzalez-Hoelling, Bertran-Noguer, Reig-Garcia, & Suner-Soler, 2021). Other studies did show significant improvements in balance (Cha, Kim, Hwang, & Chung, 2014; J. O. Kim, D., 2012).

Although this study tried to provide an indication of the possible rehabilitation benefits of music-based treadmill training in cerebellar patients, there are still some limitations present. Because of the case study format, it wasn't possible to provide adequate statistical analysis. The sample size is too small and without any comparison to controls, ensuring that this study couldn't show any effects. Furthermore, a part of the pre-testing was performed by an English-speaking person without a translator present. This probably influenced the testing because the participant didn't fully understand the tasks. Also, the pre-and post-testing contained many tests one after another performed in a random order. Although many breaks were included to rest, it still took a lot of effort from the participant and it was possible that later tests were less well executed because of fatigue or fatigability. Moreover, the participant in this study had been in rehabilitation for over a year and had progressed much before entering the study. Therefore, the results of this study weren't representative of more acute cerebellar cases. The intervention itself was also under the supervision of two different researchers, but precautions were taken to standardise the performance of this study. The two different researchers were trained to provide exactly the same protocol during the multiple sessions. The intervention took place on the same weekdays and hours (one-day exception because of a holiday). Finally, the absence of synchronization outcome measures such as the rPA and RVL in this study prevented the possible conclusions on this subject. Therefore, the recommendation is to apply these synchronization outcome measures in further research.

Further, this study provided the information that a walking to music intervention on a treadmill can possibly improve balance in patients with cerebellar problems. Additionally, this intervention can enhance a reduction in anxiety and depression as well as cognitive and physical fatigue. Even to the extent that participants' would want to adopt walking to music in their daily lives.

Regardless of a lower level of evidence due to the study format, these results sparked an interest for more research regarding walking to music interventions on a treadmill in patients with cerebellar problems. Therefore, further research with larger sample sizes is needed to address the feasibility and effectiveness of a walking to music intervention on a treadmill in patients with cerebellar disorders. There it would be interesting to include more severe cases of cerebellar disorders, such as ataxic patients. A synchronization task of the upper extremities could then be included to investigate whether ataxic patients are able to synchronize and if the ataxia itself is adjustable by synchronizing to music.

2.6. Conclusion

This master thesis contained a walking to music intervention on a treadmill in a patient with a cerebellar disorder. The results of this master thesis indicated that a positive effect on balance as well as perceived fatigue and motivation is possible. However, further research on this topic in patients with cerebellar disorders is still necessary.

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4. Appendices

4.1. Appendix 1 – Details testing and intervention

	Timing	Duration	Provided by	Place
Pre-testing	1 week before the intervention	2h	Lousin Moumdjian* Lotte Poukens**	Noorderhart Rehabilitation & MS centre
Session 1	Monday week 1	30 min	Lotte Poukens	
Session 2	Friday week 1	30 min	Lotte Poukens	
Session 3	Monday week 2	30 min	Lotte Poukens	
Session 4	Friday week 2	30 min	Lotte Poukens	
Session 5	Thursday week 3	30 min	Lotte Poukens	
Session 6	Friday week 3	30 min	Lotte Poukens	
Session 7	Monday week 4	30 min	Anne Ceulemans***	
Session 8	Friday week 4	30 min	Anne Ceulemans	
Post-testing	1 week after the intervention	2h	Anne Ceulemans Febe Schuurmans*** Lousin Moumdjian	

**postdoctoral researcher; **student 2nd master physical therapy; ***student 1st master physical therapy*
BPM: beats per minute; h: hour; min: minutes

4.2. Appendix 2 – Songs used during the intervention

	Artist and title	BPM	Genre	Familiarity of the music*	Liking of the songs*
Week 1	Shades of the Abyss - Sanctum	72.74	Instrumental	S1: 1 S2: 2	S1: 4 S2: 4
	Musique de la Legion Etrangere - Marche de la Legion Etrangere	82.50			
	Adrian Von Ziegler - Wolf blood	84.86			
	Instrumental Core - March of warriors	89.89			
	Hector Berlioz - Hugarian march	91.46			
	Michalis Nikoloudis - Armenistis	92.50			
Week 2	Twenty One Pilots - Ride	75.00	Pop-rock	S3: 3 S4: 3	S3: 4 S4: 4
	Foreigner - I want to know what love is	81.83			
	John Lennon - Watching the wheels	82.56			
	Hoobastank - The reason	82.98			
	All That Remains - For you	92.01			
	Adam Lambert - Whataya want from me	93.01			
Week 3	Passenger - Let her go	75.00	Soft-pop	S5: 5 S6: 3	S5: 4 S6: 4
	Ed Sheeran - Thinking out loud	78.99			
	Sam Smith - I'm not the only one	82.01			
	Emilie Simon - Desert	82.05			
	Olly Murs - Hand on heart	88.98			
	Sade - Your love is king	89.79			
Week 4	Timbaland ft. Elton John - 2 man show	70.00	Pop	S7: 1 S8: 3	S7: 4 S8: 4
	Amy Winehouse - Rehab	72.00			
	Beyonce - Rather die young	72.00			
	Rag'n'Bone Man - Human	75.00			
	Anna of the North - Thank me later	77.00			
	Massive Attack - Teardrop	77.01			

*BMP: beats per minute; S: session; *scored on a Likert scale 1-5*

<u>4.3. Appendix 3 – Progress form</u>

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DATUM	INHOUD OVERLEG	HANDTEKENINGEN
21/10/'21	• ethical commission	Promotor: / Copromotor/begeleider: Student(e): Student(e):
5/2/'21	• discussing the protocol • making a timeline	Promotor: / Copromotor/begeleider: Student(e): Student(e):
6/4/'21	• discussing progress • explaining data-analysis	Promotor: / Copromotor/begeleider: Student(e): Student(e):
27/4/'21	• discussing statistical procedures	Promotor: / Copromotor/begeleider: Student(e): Student(e):
28/5/'21	• feedback final version by Lousin Moumdjian (mail)	Promotor: / Copromotor/begeleider: Student(e): / Student(e):/
31/5/'21	• feedback and approval final version by Peter Feys (mail)	Promotor: Copromotor/begeleider: / Student(e): / Student(e): /