

# *An innovative visuolocomotor training program for vestibular rehabilitation: A pilot study conducted on waitlist patients*

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**ABSTRACT:** Dizziness and imbalance are debilitating symptoms of vestibular dysfunction (VD) that can be treated through vestibular rehabilitation. The C-Mill ForceLink treadmill (C-Mill) incorporates visual and auditory cues for the treatment of gait. C-mill training allows for the integration of virtual reality and cognitive dual-tasking during treatment. No research has been conducted on its use in vestibular rehabilitation. The purpose of this pilot study was to develop a visuolocomotor training program and evaluate its feasibility in patients who were on the waiting list for vestibular rehabilitation using the C-Mill. The intervention consisted of 10 one-hour sessions on the C-Mill. The Dizziness Handicap Inventory (DHI), Visual Vertigo Analog Scale (VVAS), and Functional Gait Assessment (FGA) were used as outcome measures, in conjunction with 3 open ended questions on their goals and satisfaction with the intervention. . Nine participants who were referred for vestibular rehabilitation by an otolaryngologist completed the study. The majority (5/9) demonstrated improvement in all functional outcome as well as subjective reports, while none digressed. The average percent of improvement from defined baseline to follow-up was 42.43% for the DHI (standard deviation (SD)=23.82%), 54.59% for the VVAS (SD=31.95%) and 21.89% for the FGA (SD=33.64%). Results support the use of the C-Mill as an intervention for patients on a waiting list with VD under the supervision of a physiotherapist. A larger and more comprehensive study is feasible in order to further investigate the effects of this protocol on symptoms of dizziness and imbalance in individuals with VD.

*Keywords—Vestibular rehabilitation, augmented reality training, dizziness*

## I. INTRODUCTION

Dizziness and imbalance are common symptoms in people with vestibular dysfunction (VD). Vestibular symptoms have a lifetime prevalence of 20-40% in the general population and can be treated through vestibular rehabilitation[1]. Based on findings from a clinical examination, physiotherapists provide specific interventions to promote rehabilitation of the vestibular system through adaptation (capacity of the vestibular system for neuronal changes), substitution (alternate strategies to replace the lost vestibular system), and habituation (long-term reduction in the response to provocative stimuli by increasing the threshold to dizziness)[2]. A variety of treatment strategies can be used to achieve these goals.

The vestibular system is integral in maintaining normal balance. Individuals with VD often rely more heavily on cognitive resources to maintain their balance[3]. Although the existing literature on the use of cognitive dual-tasking in vestibular rehabilitation is limited, it is clear that the vestibular system has a substantial impact on cognitive functions like visuospatial ability, attention, executive function, and memory[4]. Clinically, ‘brain fog’ and memory loss are common symptoms in patients with vestibular vertigo and dizziness, highlighting the link between VD and cognitive impairment[5]. The addition of a cognitive dual-task during vestibular rehabilitation places further demands on cognitive resources, increasing task complexity. When walking on a straight path, for example, patients with VD experienced more veering and decreased speed when cognitive tasks were added compared to healthy controls[6]. In their recent review, Deveze and colleagues discuss both cognitive dual-tasking and virtual reality as being new trends in vestibular rehabilitation. They conclude that dual-tasking may be a useful tool to improve postural control in clients undergoing vestibular rehabilitation[7].

There is strong evidence to support the use of virtual reality in vestibular rehabilitation[8]. Repetitive visual motion stimulation is used in virtual reality to achieve visual desensitisation for individuals with VD who have increased dizziness and postural instability in response to this stimulation[9]. Visual inputs and active head movements in virtual reality training lead to adaptation and decreased dizziness via changes in the central nervous system (CNS)[10].

For this study, the C-Mill was used to incorporate both cognitive dual-tasking and virtual reality as an intervention for VD. The C-Mill is a treadmill (walking area 70 x 300 cm) that offers visual and auditory cues for training and evaluation of gait patterns. It provides an environment where users can perform visuolocomotor training in a controlled and safe manner. The treatment protocols are modifiable and controllable through computer software. Protocols can include the projection of images on the treadmill, incorporating visually guided stepping, speeding up/slowing down, obstacle negotiation, and gait-adaptability games. In combination with a large television screen, it offers clients

with VD an opportunity for cognitive dual-tasking in a modified virtual reality condition (see examples in Figure 1).

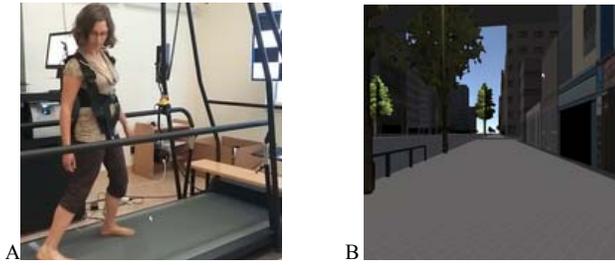


Figure 1. (A) subject walking on the C-mill alternatively stepping over the line and looking at the checker board, (B) a simple city scene moving at the same pace as the subject.

Currently, at the rehabilitation hospital where this study was performed, there are approximately 45 individuals with VD awaiting vestibular rehabilitation. The waiting time prior to evaluation is approximately one year. In this study, we investigate whether a treatment protocol with the C-Mill can reduce symptoms of dizziness and imbalance during this waiting period.

To our knowledge, this is the first study examining a C-Mill training protocol on symptoms of dizziness and imbalance in individuals with VD. Several studies have shown the C-Mill to be a promising therapeutic tool to improve gait adaptability in clients with different levels of walking ability, including those with chronic phase stroke[11], fall-related hip fractures[12], cerebellar degeneration[13], amputees[14][15], and children with cerebral palsy[16]. However, due to the novelty of this technology, clinical practice guidelines and ideal parameters have not yet been established. This study would add to the limited body of knowledge about the use of C-Mill technology in rehabilitation. The results of this study may also contribute to the existing literature on the use of virtual reality and cognitive dual-tasking in vestibular rehabilitation.

## II. METHODS

Participants were identified through a waiting list for vestibular rehabilitation in an 8-week period. This included patients who had returned to the waiting list due to persisting symptoms, having previously received treatment. Referrals were initially screened by a physiotherapist to exclude those with benign paroxysmal positional vertigo (BPPV). Participants were recruited if they met the following inclusion criteria: over 18 years of age, physician referral indicating VD, not presenting with comorbidities that could contribute to dizziness and/or imbalance (e.g. stroke, CNS pathology, vascular dysfunction, significant musculoskeletal injury), and able to ambulate without a walking aid or prosthetic device. Participants provided informed consent prior to entering the study. The study was approved by the local ethics committee.

The training consisted of 10 1-hour sessions, completed over an average of 5 weeks. The protocol consisted of a warm-up, followed by 6 tasks of 3-10 minutes each, ending with a cool-down period off the treadmill. The protocol used programs projected directly on the treadmill, and/or displayed on a large television screen in front of the treadmill. A soundtrack matching the scenes was integrated into the tasks. Clients were asked after each task to rate their symptoms on a 0-10 scale. The amount of breaks (if any), treadmill speed, and task progressions were recorded. Task duration and progression were determined based on subjects' reported symptoms and baseline status, with the goal of completing each of the 6 tasks (see Table I) of the protocol within the 1-hour session. Participants wore a safety harness, and emergency off switches were available to ensure safety at all times.

TABLE I. TASK COMPONENTS OF THE C-MILL PROTOCOL

Task	Description	Progress	Rationale
(1) City Scene	Subjects walked at a comfortable speed while looking at a scene displayed on the screen simulating walking in a city.	<ul style="list-style-type: none"> <li>simple city with decreased visual stimulus and no sounds</li> <li>complex city with increased visual stimulus and sound effects</li> <li>visual tracking of moving objects</li> <li>adding head movements in frontal, sagittal and transverse planes</li> <li>adding eyes opened and eyes closed component</li> </ul>	<ul style="list-style-type: none"> <li>gradual increase in visual stimuli</li> <li>addition of sound to increase stimulation and increase resemblance to daily life</li> <li>addition of head movements to challenge the vestibular system</li> <li>decreasing dependence on visual input to maintain balance</li> </ul>
(2) Stepping On a Line	Subjects walked at a comfortable speed and stepped on an approaching line projected onto the C-Mill	<ul style="list-style-type: none"> <li>visual tracking of the line (looking over shoulder) after stepping on it until the line turned red</li> <li>finding numbers on a checkerboard displayed on the screen after tracking the line</li> <li>progression of checkerboard dimensions (4x4, 5x5, 6x6, 7x7, 8x8)</li> </ul>	<ul style="list-style-type: none"> <li>addition of head movements to challenge the vestibular system</li> <li>addition of visual stimulus and cognitive dual-task</li> </ul>
(3) Colourful Walls Scene	Subjects walked at a comfortable speed while looking at a scene displayed on the television, simulating walking straight in a corridor with walls of various blocks of colours.	<ul style="list-style-type: none"> <li>adding head movements in frontal, sagittal and transverse planes</li> <li>adding the 'Stroop colour-word' cognitive task*</li> <li>stop and go (subjects were asked to stop walking, then to continue walking after a delay)</li> <li>'spiral' version of the same scene, which could be moving forwards or backwards</li> </ul>	<ul style="list-style-type: none"> <li>looking at the moving scene to provoke visual vertigo</li> <li>addition of head movements to challenge the vestibular system</li> <li>addition of a cognitive dual-task</li> <li>'spiral' version to increase visual conflict</li> <li>multi-tasking</li> </ul>
(4) Side-Stepping Over a Line	Subjects side-stepped over an approaching line projected onto the C-Mill.	<ul style="list-style-type: none"> <li>visual tracking of line before and after stepping over the line</li> <li>increasing frequency of changing sides (i.e. facing to the left of the C-Mill, then facing to the right)</li> <li>finding numbers on a checkerboard displayed on the television after stepping over the line</li> <li>progression of checkerboard dimensions (4x4, 5x5, 6x6, 7x7, 8x8)</li> </ul>	<ul style="list-style-type: none"> <li>promotes head movements to left and right in a movement pattern (side-stepping) that the vestibular system has not likely integrated</li> <li>addition of visual stimulus and cognitive dual-task</li> </ul>
(5) Office Hallway Scene	Subjects walked at a comfortable speed while looking at a scene displayed on the screen, simulating walking through an office hallway with numbered doors.	<ul style="list-style-type: none"> <li>reading 3-digit numbers forward and backward</li> <li>adding cognitive task of simple arithmetic calculations with the numbers</li> <li>adding head movements in frontal, sagittal and transverse planes</li> </ul>	<ul style="list-style-type: none"> <li>commonly encountered environment</li> <li>addition of head movements to challenge the vestibular system</li> </ul>

The timeline of the study included a baseline phase (week 0), a training phase (weeks 1-6), and a follow-up session (week 7). The baseline phase consisted of two assessment sessions scheduled one week apart (baseline and pre-intervention). The training phase consisted of 10 sessions over 5 weeks. Data was collected after the 5th session (mid-intervention) and following the last (10th) session (intervention termination). A follow-up assessment session was scheduled one week following intervention termination.

Clinical outcome measures were used. The Dizziness Handicap Inventory (DHI) is a 25-item questionnaire that evaluates the impacts of dizziness and imbalance in daily

activities, incorporating the physical, functional, and emotional dimensions of VD. It is a validated and reliable tool, and especially useful in measuring changes in symptoms after a vestibular intervention[17]. The Visual Vertigo Analogue Scale (VVAS) is a nine-item analog scale that evaluates visual vertigo (i.e. dizziness induced by dynamic visual stimuli), where each item describes a daily situation that typically triggers visual vertigo. Due to the novelty of this tool, limited research is available on its psychometric properties, however, it has been found to have good clinical utility[18, 19]. The Functional Gait Assessment (FGA) is a 10-item walking test that evaluates postural stability and is used as an assessment tool in various balance disorders. It demonstrates good reliability and concurrent validity with other balance measures in the vestibular population[20]. Participants completed the DHI, the VVAS, and the FGA at baseline, pre-intervention, mid-intervention, intervention termination, and follow-up (see Figure 2).

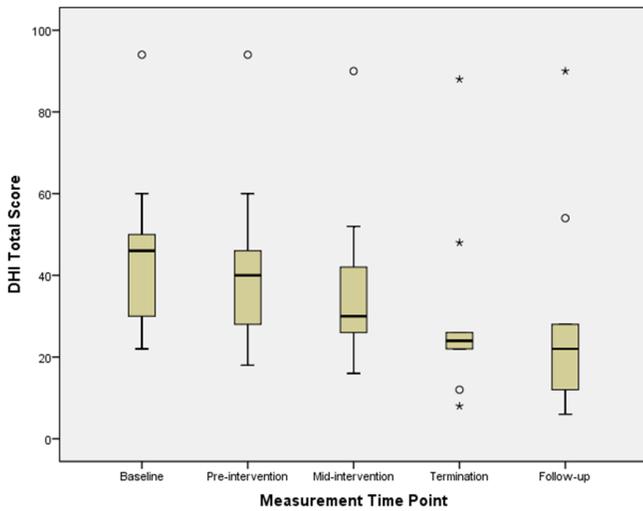


Figure 2. Boxplot summary of DHI total scores for all participants.

Subjects were also asked to complete a subjective questionnaire at the follow-up session, in which they were asked: 1) What was (were) the reason(s) for which you sought vestibular rehabilitation? 2) Out of 10 (0 being not at all, 10 being greatly), how much did the C-Mill ForceLink training help? 3) If you found that it helped, in what way(s) did it help? This questionnaire was used to assess the impact of the intervention as perceived by the participant.

### III. RESULTS

*Participants:* Of the 24 people on the waiting list who were contacted, 10 agreed to participate in the study. One subject withdrew from the study after the baseline assessment for personal reasons. 9 participants completed the study. After analysis of the results participants were then classified as responders (R) and non-responders (N) (see Table II).

TABLE II. PARTICIPANTS CHARACTERISTICS

Participant Classification*	Age	Sex	Referral date	Referral diagnosis	Time since symptom onset (at follow-up)
R1	62	M	2015-05-21	labyrinthitis	~9 months
R2	69	M	2015-05-04	vestibular schwannoma	~9 months
R3	75	F	2015-03-10	viral neuritis	~18 months
R4	40	F	2015-06-16	perilymph fistula with intermittent BPPV	~128 months
R5	77	F	2015-06-16	vestibular neuronitis	~10 months
N1	73	F	2015-05-19	unilateral hyperactive labyrinth	>60 months
N2	32	M	2015-01-27	vestibular hypofunction	~9 months
N3	49	F	2015-06-22	superior semicircular canal dehiscence	>96 months
N4	75	F	2015-06-16	unknown	~5 months

*Responders vs. Non-Responders (R vs. N):* The DHI, VVAS, FGA scores, and subjective responses at follow-up were used to classify participants as ‘responders’ (R) or ‘non-responders’ (N). Responder characteristics were as follows:

1. Improvement in DHI and VVAS scores from the defined baseline only after introduction of the intervention;
2. Subjective improvement as reported by the participant.

Five participants were classified as responders and 4 were classified as non-responders, without any clear distinction due to age, sex, diagnosis, or chronicity of symptoms.

*Dizziness Handicap Inventory (DHI):* There was a strong trend toward decreased symptoms with C-Mill intervention (see Figure 2).

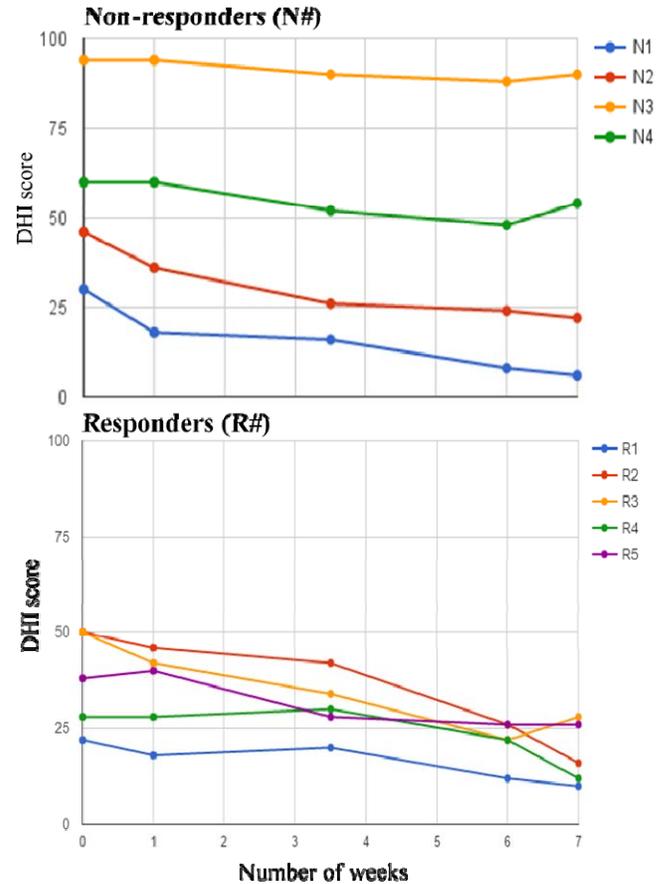


Figure 3. Individual DHI scores of (a) responders (b) non responders at Week 0 = Baseline; Week 1 = Pre-intervention; Week 3.5 = Mid-intervention; Week 6 = Intervention termination; Week 7 = Follow-up.

Of the 9 participants: 3 were classified as having a ‘mild handicap’ (0-30 points), 4 as having a ‘moderate handicap’ (31-60 points), and 2 as having a ‘severe handicap’ (61-100 points) based on DHI scores at baseline.

With intervention, 6 participants demonstrated lower DHI scores at mid-intervention and intervention termination. Two participants showed a decrease in score from baseline to pre-intervention in addition to a decrease during the intervention period. The average percent of improvement from BP (BP = the average score between baseline and pre-intervention) to mid-intervention was 16.35% (SD=15.50%), from BP to termination was 36.36% (SD=18.36%), and from BP to follow-up was 42.43% (SD=23.82%). The individual score of each subject, with the participants separated into responder and non-responder is shown in Figure 3. One participant with very severe symptoms at baseline did not demonstrate a change in DHI scores with the intervention.

*Visual Vertigo Analog Scale (VVAS):* Except for one participant, VVAS scores corresponded with DHI scores in terms of severity. In general VVAS scores decreased with C-Mill intervention (see Figure 4), though the change was smaller than the change in DHI score. Six participants demonstrated lower VVAS scores after intervention. Two participants showed a decrease in score from baseline to pre-intervention in addition to a decrease during the intervention period. One participant with severe visual vertigo at baseline did not demonstrate a change in VVAS scores with the intervention (see Figure 5). The average percent of improvement from BP to mid-intervention was 23.55% (SD=28.14%), from BP to termination was 43.58% (SD=34.90%), and from BP to follow-up was 54.59% (SD=31.95%).

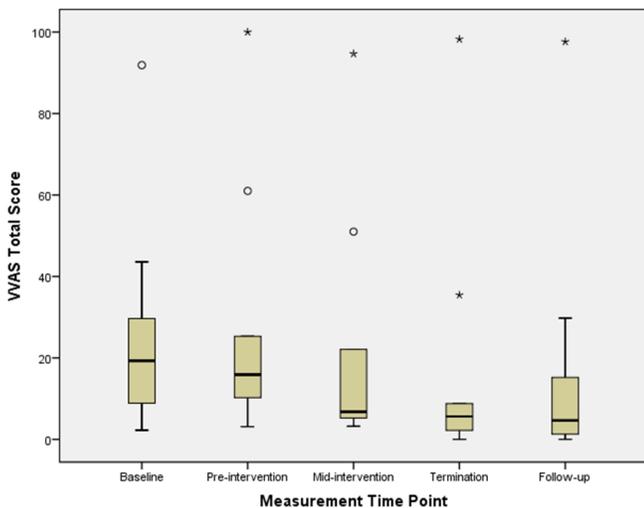


Figure 4. Boxplot summary of VVAS scores for all participants.

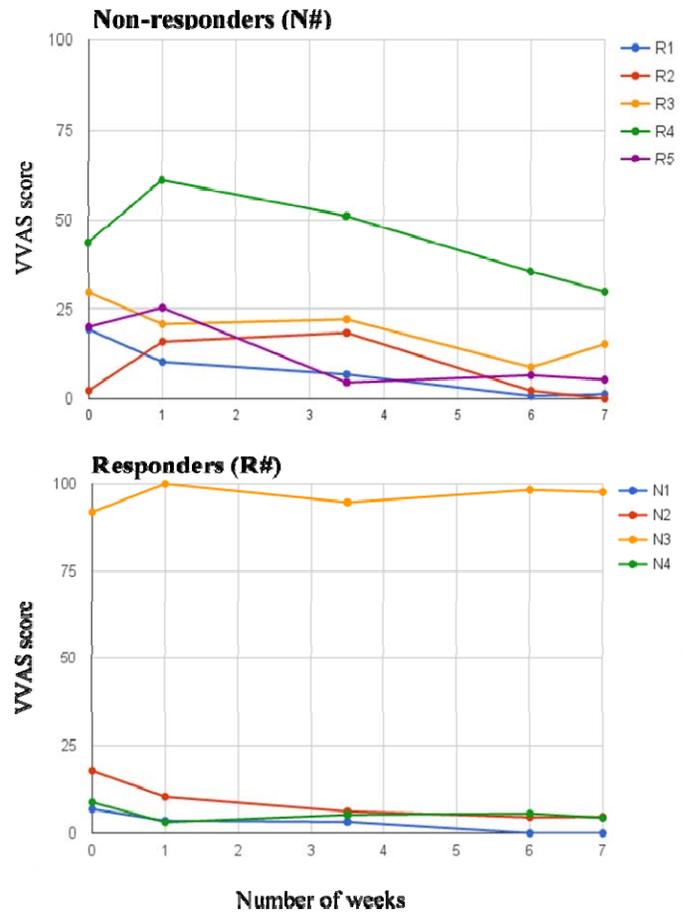


Figure 5. Individual VVAS scores of (a) responders (b) non responders at Week 0 = Baseline; Week 1 = Pre-intervention; Week 3.5 = Mid-intervention; Week 6 = Intervention termination; Week 7 = Follow-up.

*Functional Gait Assessment:* All participants demonstrated an improvement in gait as assessed by the FGA; however, 7 participants scored above 22/30 before introduction of the intervention, eliminating the possibility of obtaining a minimal clinically important difference (MCID) (a change of 8 points or more). The average percent of improvement from BP to mid-intervention was 15.74% (SD=22.07%), from BP to termination was 21.64% (SD=27.27%), and from BP to follow-up was 21.89% (SD=33.64%).

*Subjective Responses:* 4 participants reported substantial improvements (visual analogue scale (VAS) > 7) concerning daily function, confidence, and activity levels; 1 reported no improvement; 2 reported no improvement but saw benefits in terms of knowledge about the condition; 2 reported some improvement, where 1 had decreased frequency of symptoms.

#### IV. DISCUSSION

The primary goal of this study was to determine the feasibility of continued research and clinical use of the C-Mill in patients with VD. One limitation of the C-mill is that it is costly, and not commonly found in physiotherapy

departments. Our results indicate that, with adjustments, continued development of vestibular rehabilitation with the C-Mill is feasible.

In only recruiting 9 participants, we were unable to establish reliable trends regarding responders and non-responders. All the clients had symptoms for more than 3 weeks, making them chronic. We tried to control for the fluctuations in symptoms by having a baseline and pre-intervention assessment. Future research should include a larger sample size and a control group, stratified by age, diagnosis, and symptom presentation. This may increase our ability to target only those patients who are most likely to respond to this intervention.

Participants were recruited without having had a comprehensive assessment by a vestibular physiotherapist. Participant recruitment was thus based on medical diagnoses communicated through their referral. As a result, tailoring the C-Mill intervention to the participant in earlier sessions was largely experimental. Even so, participants generally progressed at a similar pace, and adjusting the training protocol's parameters and progressions could be done without difficulty. Given the unpredictability of provoked symptoms during the protocol, we recommend that the session be individualized to the user's symptoms and that progressions be gradual.

We recommend that future use of the treadmill be offered on a more flexible timeline. Further to this point, both baseline (before initiation of training) and retention (after termination of training) measures should be taken more frequently and over a longer period of time to allow the subject to reach a plateau. This will provide a more accurate indication of the effects of the training protocol itself.

Four participants showed significant increase (difference > 16 points (MCID)) in DHI scores from BP to termination, where 2 were responders and 2 were non-responders. Out of 5 responders, 3 showed a larger improvement in the second half of the treatment (after mid-intervention), indicating a potential higher effectiveness with longer period of treatment. These responses remained after one week of treatment except one responder who had a slight increase (6 points) in DHI score at follow-up. Out of 4 non-responders, 2 showed no improvement from baseline to post-intervention (difference < 6 points). When the participants were offered individual sessions of vestibular rehabilitation, only one client (N1) felt they needed further treatment.

For 7 of the 9 participants, VVAS scores were less than 30/100 at baseline, indicating mild visual vertigo. Though the improvement in VVAS scores was similar to that of the DHI scores after introduction of the intervention, it was noted that participants' symptoms were not primarily provoked by visual stimuli, which explains the lower VVAS scores. Rather, symptoms might have been provoked due to the simultaneous performance of various tasks involving head movements and gaze stability exercises in addition to the visual stimuli.

The FGA provided an objective and functional outcome measure to determine participant changes in various walking tasks throughout the intervention. However, it was not possible to see a MCID (difference of 8 points) from pre-intervention for 7 participants (pre-intervention scores were already > 22/30). Furthermore, 3 of these 7 participants were classified as non-responders and were able to perform well on the FGA despite persistent symptoms.

Participants were categorized on how responsive they were to treatment and classified as either responders (R) or non-responders (N). This classification allows for a better visual interpretation of the response to treatment when taking into account DHI, VVAS and FGA scores. In the 5 responders, 4 demonstrated an improvement that was both perceived by the participant and demonstrated objectively; one participant improved objectively but did not perceive a difference in symptoms. In the 4 non-responders, subjective and objective responses were consistent with minimal improvement in symptoms despite having increased FGA scores.

Diagnosis of VD is a complex process involving a number of different clinical and diagnostic tests[21]. As a result, misdiagnosis is possible, and relying on physician referral for obtaining a diagnosis may result in an unintentional inaccuracy. For example, a non-responder in our study was prescribed a blood pressure medication during the intervention, and she felt that this decreased her dizziness. According to Zeigelboim and colleagues, increased arterial blood pressure has been shown to affect the peripheral vestibular system due to a reduction in inner ear oxygenation[22]. This may indicate that her blood pressure was a causal factor in her VD, and/or contributed to her dizziness or imbalance.

It was noticed that if dizziness symptoms were not provoked during the first few sessions on the C-Mill, the participant was likely a non-responder. The sessions included common movements and situations that provoke dizziness in people with VD. The lack of symptom reproduction led us to consider misdiagnosis as a possible factor for non-responsiveness (n=2). In addition, for either habituation or adaptation to occur, symptoms must be provoked. Therefore, it is not surprising that the afore-mentioned participants did not respond, given the absence of symptom reproduction.

Patients with VD often experience bouts of dizziness and imbalance in an unpredictable and uncontrollable manner, which can lead to anticipatory anxiety, phobic fear and social avoidance[3]. Avoidance of certain environments and movements that may provoke dizziness leads to decreased opportunities for compensation. This compensation is a type of learning that is affected by psychological factors such as anxiety, arousal, attention, and motivation[23]. In our study, a non-responder with severe symptoms reported being unable to do many of her daily activities. During the protocol itself, she was unable to tolerate any sound or intense visual stimuli and frequently complained of daily debilitating symptoms.

We theorize that her avoidance of these tasks and stimuli may have been, in part, due to anticipatory anxiety, thus impeding her responsiveness to the intervention. The c-mill intervention may have been a stimulus too intense to allow recovery for this client.

Self-efficacy is a significant factor in recovery from balance disorders, as it is likely to mediate an individual's choice of activities both within a treatment session and in one's daily activities[24]. Therefore, participants who were able to maintain high self-efficacy and a positive outlook may have been more responsive to treatment. Further to this point, responders may have been more comfortable with their condition, and therefore more proactive and independent in pushing themselves to do more challenging activities.

Subjective responses were analyzed and overall demonstrated some form of improvement in the participant's condition. In the responder category, participants expressed that the C-Mill provided relief in symptoms of dizziness and imbalance in activities of daily living. One of the responders stated, "I'm now able to increase my activity level greatly and I hardly have any symptoms of imbalance/dizziness. Also my energy levels have dramatically increased and I'm extremely happy about that!" Another responder expressed that due to the protocol he is now able to ride his motorcycle, a leisure activity he was unable to participate in prior to the intervention. Also, a non-responder expressed that his dizziness frequency decreased after this study although his symptoms were not completely eliminated. In addition, even non-responders found they gained valuable knowledge and were interested in participating in future research.

In clinic, habituation is traditionally promoted by creating situations that will provoke clients' symptoms. Exercises often begin with simple tasks (e.g. head movements while seated), progress to more complicated visual stimuli (e.g. patterns of bullseye or checkerboards) while standing, then eventually walking. As part of this traditional approach, clients are given home exercise programs (HEPs) to be performed in brief spurts multiple times per day. By their nature, these HEPs are self-paced, meaning that clients may not challenge themselves to the same level of intensity as that experienced in this study. By contrast, the protocol used within this study was intensive, externally paced, and progressed quickly. This may have allowed the clients to challenge themselves, and consequently to see larger gains in a shorter period of time.

Despite minimal visual vertigo in most of our participants, it is a common symptom in people with VD. An effective strategy to treat visual vertigo is to desensitize patients' hyperactivity to visual stimuli by exposing them to such stimuli[25]. Since the C-Mill training protocol was in part designed for this purpose, its use as a treatment tool in individuals with visual vertigo is advocated. Furthermore, repeated and gradual exposure to visual stimuli is successful in decreasing dizziness and related psychological symptoms beyond what is achievable with conventional vestibular

rehabilitation[9]. Future research should include a subgroup of patients with visual vertigo to determine if the C-Mill protocol is more effective for their rehabilitation when compared to patients that do not experience visual vertigo.

Recently, Alahmari and colleagues conducted a study that compared outcomes of a virtual reality-based program on a treadmill to a customized physical therapy intervention for the treatment of VD. After a 6-week intervention, both groups of participants demonstrated a significant improvement in symptoms, with no between-group differences[26]. In light of these conclusions, further investigation is warranted to determine whether the incorporation of a training program on the C-Mill into a physical therapy intervention would be more effective in decreasing VD symptoms than either intervention alone.

## V. CONCLUSIONS

The primary goal of this study was to determine the feasibility of continued research and clinical use of the C-Mill in patients with VD. Our results indicate that continued work in this domain is both feasible and promising.

We recommend that future use of the treadmill, in both research and clinical domains, be offered on a more flexible timeline over a longer period of time. Further to this point, both baseline and retention measures should be taken more frequently and over a longer time span to allow the subject to reach a plateau. Future research should also include a larger sample size, allowing for subjects to be categorized by age, sex, diagnosis, and chronicity of symptoms.

Our results support the use of the C-Mill as an intervention for patients on a waiting list with VD under the supervision of a physiotherapist. A larger and more comprehensive study is feasible in order to further investigate the effects of this protocol on symptoms of dizziness and imbalance in individuals with VD.

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