Chronic Ambulatory Stroke Survivors: Is It Safe to Walk Faster?

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Abstract

Various interventions have been proposed that target improving mobility and walking speed of stroke survivors. A typical course of physical therapy that targets increasing walking speed does not guarantee that a person is “safe” in terms of their mobility. The literature can point to no conclusions regarding the walking performance benchmarks that would be necessary in order to maximize safety and how to assess them in an integrated approach. As 40% of all stroke survivors suffer serious falls within a year after their stroke, clinicians should be cautious when treating stroke patient to increase their walking speed and that there is a need for assessment batteries that comprehensively assess threats to mobility safety in chronic ambulatory stroke survivors. This review is details the available research on factors related to mobility falls in chronic ambulatory stroke survivors. This research also propose future research using Dynamic Visual Acuity (DVA) as an assessment methodology which will combine three factors that are related to mobility-related fall risk, i.e., vision, fast walking and dual-task walking.

Keywords: Walking speed; Safety; Chronic stroke; Balance; Dynamic visual acuity

Introduction

Following a stroke, independent ambulation is a major long-term goal after rehabilitation. Although 60% to 80% of stroke survivors achieve this goal, significant gait deviations persist. Such gait deviations include decreased walking speed and walking endurance compared to age-matched health adults [1-3]. Many gait-oriented therapeutic intervention have been shown to be effective to improve gait parameters following a stroke [4,5]. However, the walking safety at higher speeds following treadmill training compared to pre-training condition must be addressed. The lack of such knowledge represents an important problem considering the high prevalence of mobility-related falls in this population. Accordingly, findings from the literature on gait-oriented training, safe-mobility assessment and the associated threats to mobility safety in chronic ambulatory stroke survivors must be analyzed. Such analyses will highlight research directions to enable the optimal recovery and maintenance of mobility safety after gait-oriented interventions.

Purpose

Following a stroke, independent ambulation is a major long-term goal after rehabilitation. Although 60% to 80% of stroke survivors achieve this goal, significant gait deviations persist. Such gait deviations include decreased walking speed as compared to age-matched health adults. Physical therapy interventions that targets increasing walking speed does not guarantee that a person is “safe” in terms of their mobility. What are the performance benchmarks would be necessary in order to maximize safety? Presumably both cognitive, visual and motor ability would have to be assessed. The purpose of this literature review is to detail the available research what factors contribute to mobility falls in chronic ambulatory stroke survivors. The review will also propose guidelines for an assessment battery on how stroke population can be assessed in terms of mobility safety can safely walk and minimize risk of falls. The lack of such knowledge represents an important problem considering the high prevalence of mobility-related falls in this population.

Background

Motor impairment following stroke

Stroke has been shown to be significantly contributed to long term disability and declined Quality of Life (QOL) [6,7]. Some sensory-motor deficits following a stroke may affect both sides of the body with more evident deficits in the contralateral to the lesioned brain hemisphere and include: weakness [8], postural instability [9] and abnormal movement synergies [10]. Subsequently, significant gait impairments including decreased walking speed with decreased cadence [2] and incorrect timing of components within a movement pattern [3] persist even years following stroke. Considering the high mobility recovery rates following stroke [1,11], stroke survivors walking speeds are significantly impaired [12-14] resulting in impaired community ambulation [15]. During the recovery process, especially following rehabilitation, one can reasonably argue that the true motor recovery of gait following stroke has not been fully addressed. First, researchers have suggested that given the appropriate training paradigm, motor improvement in gait can be achieved in the chronic stage of stroke. Though, in the chronic stage, stroke patients are at higher risk of falls during mobility [16]. Second, factors related to fall in chronic stage are not entirely examined following rehabilitation and after discharge. Third, researchers have indicated that clinicians should be cautious when treating stroke patient to increase their walking speed and that there is a need for assessment batteries that assess reactive balance [16] and vision (blurred vision) [17] especially during environmental interaction that would require those patients to walk-and-talk [18] or walk faster [16] along with their common visual deficits [19]. However, there is a lack in the assessment tools that evaluate the safety associated with the behavioral changes (mobility) of stroke survivors as part of the motor impairments especially under conditions that are commonly experienced and could negatively affect their mobility and stability. There is a need for an integrated assessment battery to comprehensively assess factors which are related to persistent motor impairment after discharge from rehabilitation in stroke survivors. This understanding will be necessary toove the motor
impairments following stroke and help researchers and clinicians understand the potential contribution of cognitive and visual functions to the patients’ capabilities to interact with various distractions in their communities.

**Motor recovery following motor rehabilitation**

As many stroke patients survive with evident declined mobility [20], various interventions have been proposed that target improving mobility of stroke survivors. A systematic review of stroke rehabilitation in 2007 revealed [14] Randomized controlled trials (RCT) that involved gait-oriented training defined as training intended to improve gait performance in terms of various gait parameters such as stride/step frequency, stride/step length, endurance and walking speed [5]. Based on the observation from the literature, the desired outcomes following specialized stroke rehabilitation basically depend on two key elements: Training intensity and task-specificity [21]. Treadmill Training is a gait-oriented exercise model that focuses on multiple physiological systems to improve mobility recovery in terms of increase walking speed by providing a task-competitive locomotor training to patients following stroke [22]. Generally, the task specificity of treadmill training is represented by several perspectives: (1) specificity and variability of practice, (2) timing (inter-limb coordination) (3) improved capacity and quality for walking (speed, strength and balance) and (4) cardiovascular training (endurance) [22]. The training intensity varied as various treadmill training intensities have been proposed. Among the different training intensities that have been suggested, the literature suggested a training intensity of 4 week, 12 session and 30 min/session and showed a significant improvement in treadmill and over-ground walking speed in stroke survivors without complications such as overexertion or fatigue [23-26]. However, what distinguishes one treadmill training from another is the variability of practice itself. Although variously proposed treadmill training interventions has been shown to be effective and share the long term goal of improving mobility, the therapy-induced recovery are not yet well understood [5].

For example, Structured Speed-Dependant Treadmill Training (STT) has been introduced as a treadmill training technique that is based on the principles of sport physiologic approaches including circuit training [27] and aerobic exercises [28]. According to the sport physiologic approaches, treadmill training that is performed at speeds below the trainees’ maximum walking speed will not induce improvements in walking speed. Subsequently, STT is a sprint training technique that is held at the trainee maximum speed by forcing the participants to increase walking speed, step length without overexerting them and results in inducing significant changes on overground walking speed and step length parameters in addition to increased overground walking distance [24]. In a randomized controlled trial comparing three different gait training strategies, including STT, limited Progressive Treadmill Training (LTT) and Conventional Gait Therapy (CGT) on ambulatory stroke survivors; has shown significant improvements in mobility as evidenced by increased walking speed, cadence, stride length and functional ambulation following STT compared to LTT and CGT [26]. However, the criteria for assessing and defining the true motor recovery in term of safe mobility have been ambiguous, considering the high incident of frequent falls in chronic stroke survivors [16]. Lamontagne and Fung [29] examined the extent to which stroke subjects could increase their overground walking speed with respect to speed and unloading changes in different walking conditions. The study concluded that stroke subjects can increase substantially their walking speed without deleterious effects given proper instructions and a “safe” environment. In real-life, no guarantees on safe mobility is feasible as it is considered unpredictable (open) environment [30]. Abreu [31] examined the effect of environmental predictability on postural control following stroke. They concluded that patient safety performance must be assessed as part of motor recovery in both predictable (closed) and unpredictable (open) environment taking into considerations all factors associated with mobility-related falls.

**Factors related to mobility-related falls**

**Walking speed and community ambulation:** Significant gait impairments including decreased walking speed with decreased cadence persist even years following stroke [2]. Considering the critical role of walking speed for effective community ambulation [15], stroke has been shown to significantly contribute to long term disability and declined QOL and restricted community ambulation [6,7,15]. Stroke survivors walk at speeds ranging from 0.4 to 0.85 m/s [5,12-14], which may be insufficient for effective community ambulation. However, usual walking speed after a stroke can be ranked into clinically meaningful functional community ambulation classes, including household ambulation (less than 0.4 m/s), limited community ambulation (0.4 to 0.8 m/s) and full community ambulation (greater than 0.8 m/s) [32]. More specifically, a study by van de Port et al. [15] revealed a cut-off point of 0.66 m/s as an indicator for unlimited (full) community ambulation in chronic stroke survivors. However, it has also been shown that the preferred (self-selected) usual walking speed is largely dependent on visual functions (i.e., the better the visual functions the higher the preferred usual walking speed) [33,34].

**Visual functions:** Intact visual functions are required and are significantly involved in spatial orientation especially during dynamic tasks such as walking [35,36]. Furthermore, vision problems has been recently addressed among the commonly reported disabilities for people over 65 [37] and moreover in chronic diseases such as stroke [38] and has a negative influence on the QOL [38]. In fact, a recent multi-centre prospective observation study was undertaken on 323 stroke survivors revealed that 92% of them had visual impairments [19]. Impaired vision has been shown to be largely related to mortality in older adults [39] and it is reasonable to conclude that stroke survivors could share the same thread [19]. The relationship between altered visual functions and mobility has been well addressed. Studies have shown that the preferred (self-selected) walking speed were largely dependent on visual functions, i.e., the better the visual functions the higher the preferred walking speed [33]. In stroke survivors, the decreased walking speed, albeit pathological, may be a preferred walking speed and a behavioral compensation to maintain visual functions and a “safer” mechanism to maintain balance than walking at higher speeds [40]. Balance [41] and vision [33] are largely interrelated [19] and are significantly affected by increasing walking speed especially if walking at a specific speed was accompanied by a secondary task. Altogether, although increasing the walking speed in stroke patients is necessary for improving QOL and a major goal after rehabilitation, we still lack the knowledge of whether it is “safe” to increase the walking speed of those patients without examining their visio-cognitive interaction and how it would relate to their balance. So, it remains unclear what contributions gait training interventions would have to enable stroke patients to professionally master their mobility in order to maintain sufficient visual inputs and to reduce risk of fall especially when various challenges are being added that could pose a threat on their safety during locomotion.

**Cognitive functions:** Studies on healthy older adults have shown an association between cognition and physical performance [42]. In real-world settings, optimal health and intact cognition are uncommon features of aging especially following brain injuries such as stroke [43].
In fact, it has been shown recently that cognitive-behavioral syndromes are frequent consequences in chronic stroke survivors [44]. Walking at self-selected speed is an automated rhythmic motor behavior that can be performed without the need of high level of cognitive functions, but still requires an intact cognition [45]. Moreover, adding challenging tasks to usual-speed walking has been shown to have stronger association with cognitive functions in healthy old adults, including narrow-based walking [46], fast-speed walking (neuro-muscular challenge) [47] and walk-and-talk (dual-task cognitive challenge) [48]. Adding such challenges has resulted in reduced walking speed and increase gait variability and resulted in gait instability and high risk of fall [49-51]. Similarly, studies that has been done on stoke patients have shown significant effect of these cognitive challenges on mobility and balance [18,52-54]. A study has shown that even full ambulatory stroke survivors with intact cognitive function have difficulties performing two tasks, such as performing an over-ground walking-while-walking task [55]. In addition, stroke patients have limited capacity to increase their walking speed [56] and their community ambulation is determined by reactive balance, i.e., how they react with the environment to maintain balance during locomotion [15]. Accordingly, Stroke patients in everyday life may experience different neuro-muscular and cognitive challenges or even both. However, even though treadmill gait training has been shown to significantly increase the walking speed in chronic stroke survivors, we still don’t know what contributions do cognitive functions have on the outcomes and subsequently how this would affect balance especially with impaired visual functions and/or during unpredictable increasing mobility demands as when increasing walking speed.

Discussion

As independent and fast ambulation is a major long-term goal after rehabilitation, the results from the literature can point to no conclusions regarding the walking safety at high speeds following gait-oriented training compared to pre-training condition. Thus, there is an urgent need for an assessment battery to assess mobility safety pre-and-post gait training interventions. Before initiating an exercise intervention to increase walking speed, factors related to mobility falls must be assessed not only separately, but also comprehensively. Three threats to mobility safety can be identified from the literature: Limited capacity such as increasing walking speed do not guarantee that a person is safe. This research proposes Dynamic Visual Acuity (DVA) for further investigation as a safety outcome following gait training rehabilitation to address visual changes along with the changes in walking abilities.

Among the earliest DVA tests [62,63], the proposed DVA test was first described in 2005 as a diagnostic tool to assess the ability to visually resolve targets during treadmill walking at one fixed speed and on healthy participants [57]. The significance of this testing methodology was that it allowed the researchers to understand visual acuity changes during dynamic activities of daily living such as walking.

In fact, considering the relationship between walking speed, cognition, balance, quality of walking and DVA, the final DVA score will be an indicator of participant's ability to interact with various challenges that would negatively affect their balance and the quality of walking. Specifically, the participants will be (1) talking (naming the direction of the “C” optotypes while (2) walking on a treadmill at a specific or different speeds and (3) performing a dynamic visual acuity test presented on a computer screen at eye level [57]. Therefore, DVA testing addresses the cognitive, fast-walking and visual challenges, respectively, which are the three threats to mobility safety identified from the literature. In other words, a significant improvement in DVA and balance scores following an intervention would indicate that the participants were able to not only walk fast but also to master their mobility more efficiently. Therefore this analysis suggests future research on DVA as a possible integrated approach to answer the question: is it actually safe for chronic ambulatory stroke survivors to walk faster? It is our hope that the results from the review will guide future researched on such important aspect of rehabilitation which will increase our understanding for the expected motor recovery following different gait interventions and raise the hope for developing motor disability following stroke.

Conclusion

The purpose of this literature review is to highlight the need for an evidence-based assessment battery to assess mobility safety in chronic ambulatory stroke survivors. The current research demonstrates that gait-oriented training can enhance mobility capacity of this population. However, physical therapy interventions targeting improving mobility capacity such as increasing walking speed do not guarantee that a person is safe. This research proposes DVA for further investigation as an assessment methodology that combines three factors that are related to mobility-related fall risk, i.e., vision, fast walking and dual-task walking. It is our goal to introduce an assessment battery that researchers and clinicians can possibly adopt to assess the safety of their patients before sending them to their communities. It also should be interpreted as a need for integrating other gait intervention programs that focuses on improving the cognitive functions and balance of stroke survivors during walking.

References


