Review Article

The Importance of Obstacle Crossing Task and Considerations After Stroke: A Review of the Literature

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Abstract

Stroke is the leading cause of serious long-term disability and gait problems are amongst the most important factors causing disability after stroke. Walking adaptability is a requisite to walk efficiently in everyday life to prevent falls. The capability for negotiating obstacles in the real life environment is important for the safety of stroke patients. Stroke patients may exhibit some movement modifications like maintaining the pre-obstacle distance, choosing the affected as lead limb before, during and after crossing the obstacle in order to increase the safety. The stroke patients who cross the obstacle more slowly due to movement modifications fail more on obstacle crossing task. There is a need for training of obstacle crossing task following stroke therefore community-based gait recovery programs including obstacle-crossing would be an effective rehabilitation strategy after stroke.

Keywords: Stroke; Obstacle crossing; Gait

1. Introduction

According to the World Health Organization, annually 15 million people suffer stroke worldwide and of these 5 million die and another 5 million are permanently disabled [1]. Stroke is the leading cause of serious long-term disability and reduces mobility in more than half of stroke survivors age 65 and over [2]. Gait problems are amongst the most important factors causing disability after stroke, approximately 20-30% of patients do not regain walking ability at discharge from hospital [3, 4]. From the patients who regain walking ability 64% obtains independent walking function whereas 14% are only able to walk with assistance [5]. Walking activity has been mentioned to be the most frequent (39-90%) factor causing falls in patients with stroke which may have both physically and psychologically severe consequences [4, 6-8]. Falls after stroke may cause injuries, ranged from minor injuries like bruises to major injuries like fractures, that vary from 8-72% [6, 9-11], and from those 0.6-8.5% constitutes fractures

[10-12]. A large proportion of fractures involves hip (45-59%) [12, 13] which is usually seen on the paretic side (76-82%) [14, 15]. It is reported that only 38% of the cases gain independent mobility after recovering from hip fractures [13]. However, these physical impacts are not the only significant consequences of falls; rather the psychosocial consequences like fear of falling (88%) are equally important which often leads to physical inactivity, activities of daily living limitations, loss of independence, social deprivation and depression [6, 10, 16, 17].

2. Walking adaptability

Walking adaptability described as the ability to adjust walking to behavioral task goals and environmental demands is a requisite to walk efficiently in everyday life which is important to prevent the devastating physical and psychological effects of falling. The control of functional walking has been described by a tripartite model consisting of stepping, equilibrium, and adaptability. The neural control model includes; firstly, the basic stepping pattern of rhythmic reciprocal limb movements to take the body forwards while supporting against gravity, secondly, the control of equilibrium to maintain the body upright in space and to keep the center of mass over a moving base of support, thirdly, the adaptive capabilities for locomotor control for adapting the environmental circumstances or changes in the behavioral goal [18]. Although the domains of walking ability include nine dimensions which are defined as; obstacle negotiation, temporal demands, cognitive dual-task demands, terrain demands, ambient demands, postural transitions, motor dual task demands, physical load and maneuvering in traffic, obstacle negotiation/crossing/clearance is a very significant and unique dimension of walking ability [18, 19]. The capability for negotiating obstacles in the real life environment is a crucial factor for the safety of patients with stroke during walking which requires a well-timed coordination between visual and motor systems for generating a proper limb trajectory and maintaining the dynamic balance [18]. It has been reported that comparing to healthy subjects patients with stroke fails more when crossing obstacles. The incidence of falling was approximately 6 times higher within the stroke patients failing the obstacle crossing task either by contacting the obstacle or losing their balance [20, 21]. In addition, it was found that the patients who cannot succeed the obstacle negotiation task crosses the obstacle more slowly and with a different pattern when compared to those patients who succeeds the task [21]. Akezaki and colleagues stated that the weight bearing rate on the paretic limb was from one of the most influential factors affecting the success of obstacle negotiation in stroke patients and thus 80.5% weight bearing rate on paretic limb would guarantee for independently achieving the task [22].

3. Obstacle Crossing Strategies after Stroke

3.1 Leading and trailing leg preference

Numerous studies emphasize that, patients with stroke exhibit different strategies during obstacle crossing when compared to healthy individuals [23-27]. It might be argued that the patients may prefer to cross the obstacle with the affected limb because they may compensate the kinesthetic loses by using the visual information while the leading limb crosses the obstacle or may prefer to cross the obstacle with the unaffected limb because the greatest potential to destabilize the body occurs when the lead limb crosses the obstacle [28, 29]. Also, there might be no preference for the affected or nonaffected lower extremity as the lead limb in patients with stroke but it is important to bear in mind that the failure rate (5.7%) is lower when the nonaffected lower limb crossed the obstacle first when comparing to the failure rate (11.2%) with affected limb first [20].

3.2 Spatial strategies

Stroke patients may exhibit some movement modifications before, during and after crossing the obstacle in order to increase the safety. When leading with the affected limb if the foot accidentally contact with the obstacle threats to balance could be minimized by the regulations such as keeping the COM more posteriorly closer to the unaffected support heel [25]. Maintaining the COM closer to the stance foot may help to reduce a trip or slip hence at the same time may limit the post-obstacle distance (time between obstacle clearance and foot contact) of the lead limb. Said and colleagues has indicated that the post-obstacle distances for both the affected and unaffected lead and trail limbs reduces after clearance in patients with stroke which may be a reason for the reduced knee extension [23, 24]. Some studies indicates that patients with stroke maintain the pre-obstacle distance (time between toe-off and obstacle clearance) before crossing in order to reduce the toe contact risk earlier in swing phase and to allow longer time to modify the limb trajectory before crossing the obstacle [21, 22]. It is specified that greater trailing pre-obstacle distance may cause more excessive hip, knee and ankle flexion that may eventually decrease the risk of toe contact during clearance [24, 30]. It is also known that when the pre-obstacle distance reduces the adduction and internal rotation movements at the ankle increases and a greater muscle activation of evertor muscles needed to control the movement which is mostly difficult post-stroke [21, 31]. Therefore, maintaining the pre-obstacle distance might serve as a safety mechanism for patients with stroke.

The increased risk of heel contact with the obstacle, especially under dual-task conditions, is one of the main safety problems during obstacle negotiation task which may eventually lead to falls [32]. Therefore, those patients may use more attentive strategies like increasing the leading toe clearance distance while negotiating obstacles [23, 31, 32]. However, as the lead limb steps over the obstacle the stability demands met by the trail limb rises, thus increasing the toe clearance while crossing the obstacle may cause some safety problems [23]. Said et al have shown that the affected trail-limb clearance over the obstacle may be reduced which would eventually increase the risk for tripping in patients with stoke [24].

3.3 Temporal strategies

In order to increase the safety of obstacle crossing task patients with stroke exhibits some temporal modifications such as increasing the post-obstacle swing time of the affected lead-limb to provide more time for the modification of the swing limb trajectory after crossing the obstacle [21, 22]. When crossing with the affected trail limb weak muscle activity of the gastrocnemius may cause inefficient immediate toe-off of the paretic lower limb. Hence, patients may reduce the crossing speed of the affected lower extremity, therefore the stance time of the unaffected lower limb lengthens and the time augments as the obstacle height increases [33]. It is known that the stroke patients who cross the obstacle more slowly fail more on obstacle crossing task [28]. It has been suggested that if the speed of gait increases after stroke the performance of obstacle crossing may improve, however, obstacle crossing speed and level over ground gait speed does not correlate due to the additional demands on both limb control and balance during obstacle negotiation [34, 35]. Therefore there is a need for training of obstacle crossing task following stroke specifically.

4. Conclusion

Effective and safe obstacle crossing strategies developed by patients with stroke would reduce fall risk and might increase their balance confidence. The increased balance confidence of patients might eventually lead to increased performance in activities of daily living and patients would have better quality of life. Therefore, due to the aforementioned circumstances community-based gait recovery programs including obstacle-crossing, which could be used as a task-oriented intervention, would be an effective rehabilitation strategy after stroke.

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