Fall 2019

Functional Training to Return to Higher Level Activities after Brown Sequard Syndrome: A Case Report

Jon Anders
University of Iowa

Functional Training to Return to Higher Level Activities after Brown Sequard Syndrome
A Case Report

Jon Anders

DPT Class of 2019
Department of Physical Therapy & Rehabilitation Science
The University of Iowa

Abstract

Background: Brown Sequard Syndrome is a rare form of incomplete spinal cord injury resulting from a lateral hemi section of the spinal cord. This disorder is most well-known for its unique presentation of loss of motor control and fine touch ipsilaterally to the lesion, and temperature and pain sense contralaterally. Patients rehabilitating from Brown Sequard Syndrome have an excellent potential for functional recovery. However, there is a limited quantity of literature concerning the role of outpatient physical therapy in helping patients regain their prior level of function. The purpose of this case report is to outline the clinical decision-making process in the later stages of recovery with the intention of helping a patient achieve their individualized goals in an outpatient physical therapy setting. **Case Description:** The patient is a 69-year-old male who was diagnosed with Brown Sequard Syndrome after waking up in the middle of the night with numbness, tingling, and a loss of motor control. He underwent extensive therapy in both inpatient and outpatient therapy setting to return to safely ambulating around obstacles and playing golf. **Outcomes:** Manual muscle tests, the Dynamic Gait Index, and Berg Balance Scale were used to evaluate the patient's progress along with qualitative observations and subjective reports. **Discussion:** Over the course of 13 months the patient was able to return to his prior level of function and achieve his personal and physical therapy goals. During this time, he underwent individualized interventions aimed at addressing the interaction between his impairments and activity limitations in a safe and progressive manner. This case provides information on potential strategies to progress patients recovering from Brown Sequard Syndrome and contributes to the current understanding of the expected recovery of functional skills in this patient population.

Keywords: Physical Therapy; Rehabilitation; Brown-Sequard Syndrome; Golf, Functional Activities; Balance; Community Dwelling Older Adults

Introduction

Brown-Sequard Syndrome (BSS) is a rare neurological condition that is well-known for its unique clinical presentation. BSS results from a hemi section of the spinal cord, and clinically manifests as ipsilateral loss of motor function, fine touch, proprioception, and vibration sense due to disruption of the corticospinal tract and dorsal columns respectively. Contralaterally, the patient will be unable to experience sensory information carried by the spinothalamic tract, which consists of pain and temperature.[1] The syndrome was first described in 1849 by Charles Edward Brown-Sequard.[2] Out of the approximate 11,000 new cases of spinal cord injury a year in the United States, BSS constitutes 2-4% of all traumatic spinal cord injuries.[2,3] However, BSS has been reported in several non-traumatic causes. Vascular changes, spondylosis, cervical disk herniations, multiple sclerosis, and compression due to tumors or cysts have all been documented as causes.[2] Even infectious diseases have been implicated as a cause of BSS.

The pure form of Brown-Sequard syndrome is exceedingly rare.[4] Instead, most reported cases are instances of partial hemi section or a complete hemi section accompanied by damage on the contralateral portion of the spinal cord. This is called Brown-Sequard “Plus” Syndrome.[4]
People with BSS have excellent potential for recovery. Even when there is complete paralysis initially patients often recover their lower extremity strength and ability to ambulate. This is true in non-traumatic and traumatic cases even after the anatomical confirmation a of tract hemisection.[5] The recovery process has been documented as beginning as quickly as day one post injury or starting up to six months afterwards. As time progresses motor recovery slows. Complete recovery can take up to 2 years, but is variable.[6]

Due to the relative rarity of BSS most of the published research concerning the topic is in the form of case reports, and most of these case reports focus on surgical or pharmacological interventions in the acute stages of the injury. There is a limited amount research about the role of the physical therapist in the interprofessional plan of care (POC). However, intensive rehabilitation has been well documented in other forms of incomplete spinal cord injury, and has been demonstrated to improve ASIA motor scores, ASIA sensory scores, and ADL scores.[7]

There is a lack of literature on specific interventions to facilitate patients’ achieving their higher-level goals in this patient population. Thus, the purpose of this case report is to delineate the clinical decision-making process in the late stages of recovery from BSS. In this specific case, the patient desired to return to navigating construction sites and playing golf safely.

Case Description

The subject of this case report is a 69-year-old white male who owns his own construction business. The patient awoke in the middle of night with numbness, tingling, and weakness in his arms and legs bilaterally. He was diagnosed with C5-C6 BSS that was likely caused by cervical stenosis and vascular occlusion. He received intensive care at a large Midwest medical center. The patient underwent an immediate C5-C6 laminectomy. After surgery addressed the emergent state of the patient, he was transferred to the acute rehabilitation unit. After two weeks, he was discharged. At that time, he could ambulate limited household distances with the use of a two wheeled walker and an ankle foot orthotic (AFO) supporting his left ankle. He used a wheelchair for traveling longer distances. The patient was not satisfied by his level of functional attainment at this time.

Physical Therapy Examination and Evaluation

Around 10 days after his discharge from acute rehab he began outpatient physical therapy. After 67 sessions, or six months, of outpatient physical therapy at an initial site the patient transferred to a second outpatient clinic and remained there for the duration of his plan of care (POC). This transfer was motivated by the patient wishing to try an alternate rehab approach. In total, he received approximately 13 months of physical therapy services on an outpatient basis.

At his initial visit to the first outpatient clinic the patient reported he had unsteadiness when ambulating, bilateral numbness in tingling in his feet that progressively worsened as he fatigued, and

"tightness" in his bilateral lower extremities. He also felt his legs were weak, especially the left. These impairments were reducing his ability to participate in the activities he used to enjoy. Namely, the patient wanted to return to his weekly golf game and be able to navigate his job sites safely and confidently.

On physical examination the patient had normal fine touch, vibration, two-point discrimination, and sharp dull sense bilaterally. He had slight, but perceptible weakness of his left upper extremity. In the lower extremities, he had identifiable weakness on manual muscle tests (MMT) bilaterally that was more pronounced on the left (Table 1). Bilaterally, the patient could accurately report two-point discrimination and fine touch. However, he was unable to accurately report sharp dull on the plantar aspect of his left foot. He had increased tone and mild spasticity in his bilateral hip flexors and quadriceps. Upon gait analysis, he walked with a slow cadence, wide base of support, and decreased hip extension on the left. The patient demonstrated a limited ability to maintain his balance in static positions but had increased difficulty as tasks became more dynamic and complex.

Table 1. Initial manual muscle test (MMT) of the lower extremities

	Initial MMT Grade R	Initial MMT Grade L	End MMT Grade R	End MMT Grade L
Hip Flexion	4/5	4/5	5/5	5/5
Hip Extension	3+/5	3+/5	4+/5	4+/5
Hip Abduction	4/5	3+/5	4+/5	4/5
Knee Extension	5/5	4/5	5/5	5/5
Ankle Inversion	3+/5	3+/5	5/5	5/5
Ankle Dorsiflexion	4+/5	4+/5	5/5	5/5

Clinical Impressions

A series of impairments that were likely limiting his capacity to achieve his goals were identified. First, his weakened lower extremities made ambulating household distances difficult, and reduced his ability to traverse obstacles. Second, his impaired dynamic balance made the rapid weight shifting required to forcibly swing a golf club hazardous. The patient also reported that he fatigued easily. He also had residual abnormal tone in his hip flexors and quadriceps. Finally, the patient displayed a lack of confidence when ambulating independently.

Since the patient had already underwent extensive physical therapy it was important to assess what the patient felt they could accomplish with additional therapy at our center. The patient stated he wanted to return to golf more than anything else, and he felt that goal was attainable. He also reported that his feet still had pins and needles sensations when balancing, and that he still didn't always feel like he could keep his balance in certain conditions. He reported fatigue made the tingling worse and adversely affected his ability to walk.

The patient had excellent rehab potential and was likely to return to his prior level of function (PLOF). This optimistic prognosis was due to the fact his injury was non traumatic and surgically managed, which has been shown to be predictive of large increases in Functional Independence Measure (FIM) scores in patients with spinal cord injury.[8] There is a limited amount of research of how this finding could transfer to the outpatient setting. His lower extremity strength had the potential to return as research has demonstrated increases in force production with continued rehab after spinal cord injury.[9] Balance, and patients' confidence in their balance, has been shown to improve with repeated exposure to demanding balance exercises.[10] Unfortunately, the symptoms resembling a peripheral neuropathy in the patient's feet were unlikely to improve due to the lack of change of those symptoms over the course of his rehab to that point.[11] This made symptom management the intervention of choice for this specific impairment.

After the patient's initial evaluation four goals were created to address his primary impairments and activity limitations while reducing his participation restrictions (Table 2).

Table 2. Patient Goals

Goal	Time Frame
Independent with weight room routine for LE strengthening by DC	By the end of the POC
Improve his bilateral lower extremity MMT grades by 1/3 along with improved trunk strength to all allow him to maintain balance on uneven surfaces for a return to golfing after DC.	By the end of the POC
Perform all dynamic gait and balance exercises demonstrating the ability to self-correct for any LOB consistently by DC	By the end of the POC

These long-term goals were created with the intent of transitioning the patient to independent management of his home exercise program and helping him return to the leisure activities he enjoys. The goals directly addressed two of his primary impairments by targeting his weak lower extremities and decreased dynamic balance. This transition to self-care is critical as it has the potential to lower his healthcare utilization and reflects a shifting of his locus of control back to him.

Management

Addressing the patient's primary impairments was key to his POC. His lower extremity weakness, difficulty maintaining his balance, and lack of motor control of his dorsiflexors forced him to use a walker and an AFO when ambulating. Strengthening in functional positions and balance activities were performed in as safe a manner as possible to begin to transition him to less restrictive assistive device. Balance and strengthening programs have been shown to effectively lower the risk for falls in patients who are 50 and older, as well as those with peripheral neuropathy.[12] The patient was also instructed in regular cardiovascular conditioning to prepare him for ambulating community distances. The patient underwent 67 sessions of therapy at this first outpatient clinic, and by his discharge he had completely stopped using the AFO and transitioned from using a two wheeled walker to a single point cane. The patient did not feel like he could return to his previous hobbies at this point, and decided he wanted to attempt therapy in a different clinic with the possibility of using a therapeutic pool. He transferred to the second outpatient physical therapy clinic to continue his rehabilitation.

Aquatic therapy was used to after the initial land-based strategy as the patient wanted to test out alternative rehabilitation strategies to address his residual impairments. Also, a patient is much less likely to be injured after a loss of balance (LOB) in a pool. In a recent meta-analysis, aquatic exercises were shown to have a positive improvement of balance in hemiplegic patients, and that it may be superior to land based balance activities for this population.[13] Exercise in the aquatic environment has also been shown to improve gait kinematics with the added benefit of reducing spasticity in patients with spinal cord injuries.[14] Walking and strengthening exercises were used in an attempt to achieve these benefits.

Land based therapies were used to supplement the patient's time in the pool. Initially, these primarily consisted of progressive lower extremity strengthening on weight machines. In a case series, patients recovering from incomplete spinal cord injuries were able to increase their lower extremity torque production after a 12 week resistance training and plyometric program.[15] Lower extremity strength was also associated with improved walking ability and velocity.[16] These exercises include leg press, knee extension and flexion in sitting, and sit to stands. These specific exercises were used as they lowered the risk of a potential fall while loading his lower extremity musculature.

As the patient progressed, concerted efforts were made to integrate functional activities into the physical therapy POC as safely as possible. Evaluating the patient's ability to perform functional tasks could serve as a benchmark by which we could chart his improvement. Also, practicing of functional tasks has been shown to increase self-efficacy for community dwelling older adults with mobility deficits.[17] These functional tasks included navigating obstacles, climbing ladders, and carrying objects. To improve his dynamic balance the patient completed exercises from the Otago exercise program which has been shown to significantly reduce falls in older adults.[18] When he was able to demonstrate that he could safely ambulate without an assistive device on level surfaces his balance program was progressed to completing Otago exercises in a grass field. This was a natural progression as the patient needed to ambulate this on terrain in order to return to golf. The patient walked up and down slopes of increasing grades as his balance improved. By the end of his rehabilitation he was able to walk perpendicular to; and backwards up and down slopes. With these interventions we saw our patient's ability to ambulate on uneven terrain greatly improve. However, it is important to note that the patient continued to report paresthesia in his feet bilaterally, and that these grew more intense the longer he participated in balance activities.

Concurrently, the patient's ability to traverse obstacles that he would commonly encounter at work was emphasized. Obstacle courses were created to simulate his work environment. These commonly included sharp turns, stepping over and around obstacles, climbing ladders, and side stepping. As the patient improved in his ability to perform these tasks, they were made more difficult with the inclusion of dual task components. Dual task training has been shown to improve walking performance in older adults.[19] Furthermore, dual tasking while practicing a specific task, such as balancing, can habituate a patient to the extra cognitive load. This can reduce the cognitive effort required when performing balance activities.[20]

After approximately 11 months of outpatient therapy the patient could reliably complete the before mentioned balance tasks with confidence, and he was progressed to carrying loads while completing them. This significantly increased the amount of torque required from the patient to maintain his center of mass inside his base of support. Load was progressed more conservatively than other aspects of his balance program as it simultaneously limited his ability to catch himself while increasing the likelihood of a severe injury if he fell. The patient at most ambulated with 40lbs. This is more than the patient's golf bag weighed.

His confidence on uneven surfaces had increased to the point he had begun playing golf in a limited capacity after 4-5 months of therapy at the second outpatient clinic. He stated he was still struggling with his swing. He was not producing enough force to drive the ball a substantial distance. The patient wanted to incorporate more sport specific training into his rehab. This process started with a functional analysis of the patient's swing. The patient brought golf clubs to a therapy session, and his golf swing was analyzed. During his swing the patient demonstrated reduced weight shifting and limited transfer of force to his front. He also had minimal rotation of his lumbar spine and hips. The end result was that he relied primarily on his upper extremities for force production. Previously mentioned balance interventions were concurrently progressed with interventions aimed at increasing torque production. Evans and Tuttle report that while driving, the head of the golf club can reach 160km/hour, and that golfers can generate up 80-90% of their maximum voluntary contraction during their swing.[21] To increase the distance our patient could drive a ball we altered our lower extremity strengthening program to include more functional positions, as strengthening programs have shown to have success in increasing club head speed in amateur golfers in a recent study.[22] Medicine ball dead lifts and slams, stair climbing, and resisted hip extension were used in addition to his other lower extremity exercises. Pallof presses, trunk rotations with a medicine ball, and our higher-level balance activities increased the stability and rotary force his trunk musculature could provide. As the patient became more proficient in these exercises, he was progressed to doing resisted cable rotations with emphasis on hip and lumbar rotation while moving upwards across his body. He also exercised moving downward diagonally across his body. These motions are similar to the D1 flexion and D2 extension patterns. The patient was tasked with throwing a medicine ball as far as he could using the driving movement. Initially he

experienced frequent LOB during the transfer of force from his lower extremity during this exercise, but as he practiced, he grew more capable of maintaining his balance, and adding distance to his throws. Finally, the patient had to catch the medicine ball after a throw to further improve his balance and core stability. After a period of 2-3 weeks his ability to rotate at the hips and lumbar spine greatly improved both subjectively and upon observation.

Outcomes

After 67 sessions of ground-based ambulation training at the initial PT clinic, and 51 sessions at the second outpatient clinic he was appropriate for discharge from physical therapy. His lower extremity MMT were roughly symmetrical and at least 4/5. Minimal detectible change (MDC) and minimal clinically important difference (MCID) for MMT are currently not established in the literature, however Cuthbert et al. found that a change must be larger than one full grade to confidently state change has occurred.[23] He greatly improved his ability to maintain his balance, and right himself when necessary. This was reflected by the patient's performance on traditionally used measures of balance. The patient initially completed the Dynamic Gait Index (DGI) near the end of his POC. His score of a 19/24 increased to a 22/24 in the time frame of three weeks. This is greater than the reported MCID (1.8) and MDC (2.8) for the DGI in community dwelling older adults.[24] His Berg Balance Score (BBS) was a 39/56 at the initial outpatient physical therapy clinic. By the end of his POC this improved to a 50/56 which is an improvement that that is greater than needed change of 4.13 for a MDC found in 2012.[25] Functionally, the patient was golfing and maneuvering around his job site without issue. He had not used an assistive device for over five months, and perhaps most importantly, his wife was comfortable with him golfing and working again. The patient was approaching his PLOF, however he still complained of occasional hip tightness and numbness and tingling in his feet that became more painful with activity. This limited his ability to tolerate continuous exercise and ambulation. After discharge, the patient began an independent workout routine with a personal trainer 3 days a week. He reported that he was satisfied with his POC, and that he had a great game of golf over the weekend.

Table 3.

Measure	MDC	MCID	Did the patient significantly Improve (Yes/No)
MMT	+-1*	+-1*	Yes
DGI	2.8	1.8	Yes
BBS	4.13	NA	Yes

*To confidently state a change has occurred the MMT grade must change by greater than or equal to one full grade. However, there is currently no established MDC or MCID for MMT.[23]

Discussion

BSS is an incomplete spinal cord injury that presents with ipsilateral loss of fine touch and proprioception and motor control and with contralateral loss of pain temperature sense. Pain fatigue, and loss of function are common aftereffects of the disease process. A consideration for any patient with neuronal damage is the time frame of potential recovery and reinnervation of the affected areas. Neuronal recovery can vary widely between individuals and sets the pace at which rehabilitation can be progressed.[6]

At the time of his examination in outpatient therapy the patient's signs and symptoms no longer resembled the classical presentation of BSS or even BSS+ but, this is not surprising. Individuals recovering from incomplete spinal cord injuries may have different rates of recovery in different areas.[6] This creates a wide spectrum of presentations which could be considered normal.

After completing outpatient physical therapy our patient was able to return to his recreational activities and navigating his construction sites. His dynamic balance improved dramatically, and balance became more automatic. Lower extremity weakness was continually addressed throughout his

POC. The patient's residual spasticity was addressed minimally, but it significantly reduced over time. Similarly, the numbness and tingling in his feet bilaterally was taken into consideration when incorporating rest brakes but was not addressed directly.

While the patient was able to accomplish all of his PT and personal goals it took him over 100 sessions of outpatient physical therapy to do so. Many patients do not have the luxury to undergo such extensive physical therapy due to financial constraints. His Initial low level of functioning combined with the natural progression after an incomplete spinal cord injury may explain part of why regaining his PLOF was such a lengthy process. Possibly, this process could have been expedited by increasing the rate at which interventions were integrated. However, this strategy may have increased his risk of injury via a fall.

For many patients, the most intense period of rehabilitation takes place in acute rehab. Here, they focus on improving their ability to independently complete their activities of daily living of their ability to safely navigate their environment. However, upon discharge, there is often a cleft between the patient's current level of functioning and their desired level community involvement. Outpatient therapy has been traditionally used to bridge this gap. There is a paucity of available research for management of BSS after the acute phase. There is also a distinct lack of research examining the effectiveness of interventions commonly used in physical therapy for patients with this diagnosis. More extensive research on what PT interventions are most effective in this population could increase the rate and efficiency at which these patients return to their prior level of functioning. Future studies should focus on understanding the differences in symptom presentation between individuals with BBS and how it affects their return to their PLOF This case report shows that extensive outpatient therapy after being discharged from acute rehab may be beneficial for to help bridge the gap between a patient's current function and their desired level of function for patients with BBS. In this case, our patient was able to make substantial improvements in his functional capabilities. Extensive outpatient physical therapy may be an appropriate step after acute rehab, for patients with BBS, and should be considered as a potential means to regaining their prior level of function.

References

1. https://rarediseases.org/rare-diseases/brown-sequard-syndrome/
2. Shams S, Arain A. Brown Sequard Syndrome. [Updated 2019 Jun 9]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing. Available from: https://www.ncbi.nlm.nih.gov/books/NBK538135/.
3. Koksal V, Prof MDA, Yavasi O, Prof MDA. Controversies in the differential diagnosis of Brown-Sequard syndrome due to cervical spinal disease from stroke: A case series. *Turkish J Emerg Med*. 2017;17(3):115-120. doi:10.1016/j.tjem.2017.05.002
4. Amendola L, Corghi A, Cappuccio M, Iure DE. Two cases of Brown-Séquard syndrome in penetrating spinal cord injuries. *Eur Rev Med Pharmacol Sci*. 2014;18(Suppl 1):2-7.
5. Little JW, Halar E. Temporal Course of Motor Recovery After Brown-Sequard Spinal Cord Injuries. *Paraplegia*. 1985;23:39-46.
6. Ginsberg L. Myelopathy: chameleons and mimics. *Pract Neurol*. 2017;17(1):6-12. doi: 10.1136/practneurol-2016-001485.
7. Wang F, Zhang J, Tang H, et al. Characteristics and rehabilitation for patients with spinal cord stab injury. *J Phys Ther Sci.* 2015;27(12):3671-3. doi: 10.1589/jpts.27.3671
8. Milicevic S, Piscevic V, Bukumiric Z, et al. Analysis of the Factors Influencing Functional Outcomes in Patients with Spinal Cord Injury. *J Phys Ther Sci.* 2014;26(1):67-71.
9. Nas K, Yazmalar L, Şah V, Aydın A, Öneş K. Rehabilitation of spinal cord injuries. *World J Orthop.* 2015;6(1):8-16. doi:10.5312/wjo.v6.i1.8
10. Halvarsson A, Dohrn I. Taking balance training for older adults one step further: the rationale for and a description of a proven balance training programme. *Clin Rehabil.* 2015;29(5):417-25. doi:10.1177/0269215514546770

11. Watson JC, Dyck PJ. Peripheral Neuropathy: A Practical Approach to Diagnosis and Symptom Management. *Mayo Clin Proc*. 2015;90(7):940-951. doi:10.1016/j.mayocp.2015.05.004
12. Tofthagen C, Visovsky C, Berry L. Strength and balance traiing for adults with peripheral neuropahty and high risk of fall: current evidence and implications for future research. *Oncol Nurs Forum*. 2012;39(5):E416-424. doi:10.1188/12.ONF.E416-E424.
13. Methajarunon P, Eitivipart C, Foongchomcheay A. Systematic review of published studies on aquatic exercise for balance in patients with multiple sclerosis, Parkinson's disease, and hemiplegia. *Hong Kong Physiother J*. 2016;35:12-20. doi:10.1016/j.hkpj.2016.03.002
14. Ellapen TJ, Hammill HV, Swanepoel M, Strydom GL. The benefits of hydrotherapy to patients with spinal cord injuries. *Afr J Disabil.* 2018;7(0):450.
15. Gregory CM, Bowden MG, Jayaraman A, et al. Resistance training and locomotor recovery after incomplete spinal cord injury: a case series. *Spinal Cord.* 2007;45(7):522-530. doi:10.1038/sj.sc.3102002
16. Dipiro ND, Holthaus KD, Morgan PJ, et al. Lower Extremity Strength Is Correlated with Walking Function After Incomplete SCI. *Top Spinal Cord Inj Rehabil.* 2015;21(2):133-139. doi:10.1310/sci2102-133
17. Sanford JA, Griffiths PC, Richardson P, et al. The effects of in-home rehabilitation on task self-efficacy in mobility-impaired adults: A randomized clinical trial. *J Am Geriatr Soc.* 2006;54(11):1641-8. doi:10.1111/j.1532-5415.2006.00913.x
18. Thomas S, Mackintosh S, Halbeert J. Does the 'Otago exercise programme' reduce mortality and falls in older adults?: a systematic review and meta-analysis. *Age Ageing* 2010;39(6):681-7. doi:10.1093/ageing/afq102
19. Wollesen B, Schulz S, Seydell L, Delbaere K. Does dual task training improve walking performance of older adults with concern of falling? *BMC Geriatr.* 2017;17(1):213. doi:10.1186/s12877-017-0610-5
20. Studer M. Making Balance Automatic Again: Using Dual Tasking as an Intervention in Balance Rehabilitation for Older Adults. *SM Gerontol Geriatr Res.* 2018;2(1):1015.
21. Evans K, Tuttle N. Improving performance in golf: current research and implications from a clinical perspective. *Braz J Phys Ther.* 2015;19(5):381-9.
22. Parker J, Lagerhem C, Hellström J, Olsson MC. Effects of nine weeks isokinetic training on power, golf kinematics, and driver performance in pre-elite golfers. *BMC Sports Sci Med Rehabil.* 2017;9:21. doi:10.1186/s13102-017-0086-9
23. Cuthbert SC, Goodheart GJ Jr. On the reliability and validity of manual muscle testing: a literature review. *Chiropr Osteopat.* 2007;15:4. doi:10.1186/1746-1340-15-4
24. Pardasaney PK, Latham NK, Jette AM, et al. Sensitivity to change and responsiveness of four balance measures for community-dwelling older adults. *Phys Ther.* 2012;92(3):388-97.
25. Flansbjer UB, Blom J, Brogardh C. The reproducibility of Berg Balance Scale and the Single-leg Stance in chronic stroke and the relationship between the two tests. *PM R.* 2012;4(3):165-70. doi:10.1016/j.pmrj.2011.11.004