Use of the Equilibrate System as a Diagnostic Tool to Assess Increased Fall Risk following a Personal Injury, even after a Prolonged Time

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Case Brief: Subject (Henry P., born 1943) suffered neural damage due to injury from a motor vehicle accident in July 1980. Despite surgery to remove pressure on spinal nerves from protruding disc material (via Laminectomy of disc L4-L5), subject suffered permanent motor nerve damage to the right foot. Though highly mobile and physically active, subject is unable to initiate or control movement of the big toe on the right foot to this day, and exhibits what is commonly referred to as "floppy toe."

Output from Henry P.'s balance assessment using the Equilibrate System indicates an increased risk for fall, especially in situations where balance is dependent on the right side. Awareness of this condition as well as active therapy (Equilibrate-based or traditional) should facilitate a reduction in Henry P.'s elevated fall risk and may even prevent a fall outright.

Balance Assessment: In April 2011, Henry P. (at 67 years of age) had his balance tested on the Equilibrate System, a non-invasive and comprehensive device for objective, whole-body assessment of balance and risk-for-a-fall (Balance Engineering LLC, Henrietta, NY). Henry P. was subjected to the full battery of standard balance tests (10 test types repeated 3 times each). A results summary is presented here and discussed below:

EQUILIBRATE SYSTEM

Balance Test Score Summary

TEST TYPE	Subject's Balance Score	Age Group Avg.	All Age Avg.	Left Foot Pressure %	Right Foot Pressure %
1 - Both feet eyes open	93.04	91.61	90.98	50.12	49.88
2 - Both feet eyes closed	92.51	87.12	86.19	48.46	51.54
3 - Right foot eyes open	29.33	72.02	79.07	0.00	100.00
4 - Right foot eyes closed	could not perform	51.42	59.12	-	-
5 - Left foot eyes open	70.98	72.02	79.07	100.00	0.00
6 - Left foot eyes closed	28.85	51.42	59.12	100.00	0.00
7 - Right foot forward eyes open	92.93	92.49	93.78	73.19	26.81
8 - Right foot forward eyes closed	76.53	77.56	84.06	76.50	23.50
9 - Left foot forward eyes open	89.57	92.49	93.78	29.79	70.21
10 - Left foot forward eyes closed	76.55	77.56	84.06	29.56	70.44

> Notes: Scores are based on a scale of 0-100. Subject's Balance Score for each test type is an average of three separate trials. Colors indicate risk-for-a-fall during individual tests: green = low risk, yellow = moderate risk, orange = high risk.

Results: Subject's balance assessment on the Equilibrate System documents quantitative results, some of which likely reflect lasting deleterious effects on his balance from the injury suffered 30 years ago. Balance dysfunction is likely to continue for the foreseeable future.

For test types 1 and 2 – normal standing on two feet with eyes either opened or closed – the subject demonstrated excellent balance and low risk for a fall, achieving scores that exceed the overall population average, as well the average of his 60-69 year-old peers.

Indications of potential balance dysfunction began to emerge when Henry P. was tested while standing on the right foot only – the foot in which he has no motor control of his big toe. With his eyes open (test type 3)

the subject's balance score was significantly lower than the overall averages of his age-peers as well as for the general population. Furthermore, Henry P. was unable to complete the single-foot eyes-closed portion of the test (type 4), even for the mere five seconds of balance required. Most subjects are able to complete this brief test and obtain a score before having the need to open their eyes or touch down with the other foot. The subject's deleterious balance function on the right side is believed to be due in large part to the motor neural injury to the big toe. Strength and control of this appendage play a significant role in both the active maintenance of balance, as well as the somatosensory feedback system that continually monitors and corrects one's equilibrium.

Assessment scores for balance test types that emphasized left-foot performance (Henry P.'s non-injured foot), while below-average for his age group, were significantly better than right foot tests and the subject was able to fully complete these tests. The system-operator's notes reflect an observation that while lifting his right foot for these tests, Henry P.'s floppy toe was evident, protruding separately from the others due to gravity.

Finally, in test types simulating walking gait, where feet are statically offset in the anterior/posterior direction (front/back), the subject's data output reflected an interesting asymmetry in the proportion of pressure between right and left foot to maintain balance. While most healthy subjects place a consistent and higher proportion of pressure on the trailing foot to maintain balance, in tests where the trailing foot was Henry P.'s injured right one (test types 9 and 10), he appeared to compensate for reduced control by moving his total center of mass forward, applying 26% more pressure on the forward foot when it was the uninjured left one (test type 10 versus 8).

Conclusion: Henry P.'s balance assessment revealed above-average balance scores for test types where balance was not heavily dependent on the right leg. For tests where right leg function was increasingly necessary for the maintenance of balance, the Equilibrate System recorded balance scores that were lower than average – in some cases significantly lower. In tests where the right leg was solely responsible for maintaining balance and the visual sense was removed (*i.e.* primary vestibular- and proprioception-dependent), the subject was unable to complete the test at all.

The subject's primary balance dysfunction is believed to be due to almost complete lack of motor control of the big toe on the right foot. This dysfunction is likely the result of long-lived neuronal damage from injury in a motor vehicle accident 30 years ago. The subject has been advised to be aware of his elevated risk for a fall when undertaking physical activity. This awareness is especially important as subject enters an age group where injuries from a fall: (a) are more likely, (b) are more likely to have adverse effects on the subject's quality of life, and (c) have the potential to lead to other serious, even potentially life-threatening conditions.

Aspects of Henry P.'s balance assessment indicate an increased risk for fall, especially in situations where balance is dependent on the right side. Awareness of this condition through assessment with the Equilibrate System should facilitate a decrease in Henry P.'s elevated fall risk and even outright situational prevention of a fall. Additional therapy (Equilibrate-based or traditional) may further reduce this risk.

The case study also provides evidence that the Equilibrate System can not only provide and document useful and objective balance-assessment data; it can also specifically pinpoint physiologic locations responsible for balance dysfunction and diagnose areas of weakness. Furthermore, Equilibrate can measure these physiological pathologies decades after an incident of personal injury.

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