STANDING FOR HEALING
THOMAS RAEBER, B. ENG.
LEVO AG

PRELIMINARY REPORT

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Subject Characteristics
The subject (Mr W.) is a 43 year old Caucasian male who sustained complete motor and sensory SCI at C5-6 in 1984. He underwent the standard course of post-SCI medical care and rehabilitation. He was a small business owner and manager in the rural Midwest. His living support system included a spouse, two small children, a large extended family and rural community. He wheeled independently in a manual wheelchair equipped with quad pegs. He reported that he required assistance to transfer into and out of his wheelchair. Mr. W reported a 3-year history of a non-healing sacral decubitus ulcer. His wife monitored and dressed the ulcer, and he received periodic follow-up from his family physician. He reported that he had not utilized a wound care nurse. Mr W. and his wife reported that he had been ill at various intervals in the last three years. They recounted an occasion in which Mr W. experienced signs/symptoms reminiscent of autonomic hyperreflexia. Mr W. was hospitalized early in 2005 and a colostomy was performed. He reports that his health had been slowly improving since the surgery and he had experienced no further episodes of hyperreflexia. His wife had not noted associated improvements in the condition of the sacral ulcer.

Physical Examination
Mr W. was a well-appearing male who sat in a custom-fabricated wheelchair. He reported that he favored this chair over commercially-available chairs because it was more durable. The back rest of Mr W.’s chair was low, reaching only to the lower thoracic spine. Mr W. sat on an inflatable immersion cushion. No gross pelvic obliquity was present. Mr W. used a tenodesis grip to manipulate objects.

Mr W. transferred with assistance to a plinth for examination of the sacral ulcer. The wound measured 3.5 cm wide by 6.5 cm long. It was covered by a scab and there was no visible evidence of infection. The borders of the wound were indurated and darker than surrounding skin. Due to the duration of Mr W.’s SCI (22 years), he was expected to have developed disuse osteoporosis of the lower extremities. Peripheral quantitative computed tomography of Mr W.’s distal tibiae revealed extensive loss of trabeculae and cortical thinning, commensurate with previous reports in individuals with chronic SCI.

Figure 1. Sacral decubitus ulcer on April 4, 2005.

Rationale for Standing
We hypothesized that unloading the sacral area could create a more favorable environment for healing of the sacral ulcer. A standing wheelchair could provide the desired unloading. The goal was to permit unloading of the sacral region without excessive transmission of compressive or shear loads to the lower limbs.

**Standing Wheelchair Training**

Mr W. received a standing wheelchair (LEVO AG, Switzerland, model LCE) for use in his home. Mr W. first attempted to use a chair with the manually-engaged standing feature, but was unable to maintain bilateral tenodesis grip while attempting a wheelchair push-up. He was therefore issued a chair with the electrically-engaged standing feature. A data logging device mounted on the chair monitored the angle of standing, which was partitioned into “bands”. The logger recorded the number of movements into each band and the duration of time spent standing in each band. An LED screen on the chair control pad provided visual feedback of band and time information to Mr W. was instructed not to rise above 20 degrees of elevation, in order to limit loading of the lower extremities but it significantly unloaded the area of the pressure sore.

During his first attempt to elevate the chair, Mr W. was closely monitored by the investigators for signs and symptoms of orthostasis or autonomic hyporeflexia. Mr W. tolerated standing at less than 20 degrees with no difficulty. Upon his return home, he was instructed to stand as often as was convenient, preferably for at least 30 minutes each session. (Because of the exploratory nature of this investigation, we did not impose more rigid compliance guidelines). He was once again strongly urged not to exceed 25 degrees of elevation. He was urged to discontinue standing if he experienced sweating, dizziness, nausea, lightheadedness, blurred vision, or headache.

Via telephone, Mr W. reported that his inability to independently transfer to the chair limited him to two or three sessions per week. He stated that he had difficulty wheeling the chair because it did not have quad pegs. An investigator contacted LEVO to obtain wheel rims with quad pegs. On May 17, 2005, Mr W. returned to the laboratory for a minor repair of the chair. On May 26, 2005 an investigator visited Mr W.’s home to measure the sacral ulcer. The wound had closed and was no longer covered by a scab. The discolored region of skin measured x 1.5 cm by 3.5 cm.

**After 6 Weeks of Standing**

![Figure 2. Sacral decubitus ulcer on May 26, 2005.](image)

After 16 Weeks of Standing

Mr W. returned to the laboratory on August 11, 2005 for follow-up. He reported that he continues to use his conventional chair for everyday mobility, but that the addition of quad pegs to his standing chair greatly improved its usefulness on uneven terrain. His standing wheelchair backrest extends to just below his shoulderblades, and Mr W. stated that he found it difficult to reach behind him and hook his wrist beneath the chair’s push-handle. He habitually performed this maneuver in his conventional chair when he needed postural support (when reaching with his other arm, for example). In his conventional chair, Mr W. was also able to arch his back to intentionally induce leg spasms, which he said made him feel better. We discussed the likelihood that the involuntary leg contractions evoked by the maneuver increased the venous return from the lower extremities, yielding a transient increase in
cardiac output and blood pressure. Mr W. reported that when he sat in his standing wheelchair, he liked to recline backward onto the anti-tip bars, which he found to be a very comfortable position for reading. He stated that he was satisfied with the performance of the standing chair, and he commented that it was “extremely well built.”

At this visit, the region of discolored skin over the healed sacral ulcer was indistinct. The skin over the region was pliable and healthy. During the course of standing, Mr W. reported no adverse effects (such as autonomic hyperreflexia or fracture). The information stored on the data logger was downloaded to a computer for analysis. Mr W. had the chair in his possession for a total of 120 days between April and August of 2005. Seven days of logger data were discarded because of software errors. Mr W. engaged the standing feature on 35 days. Thus, the standing wheelchair was utilized on 30.97% of days with available data, and on 29.17% of days in which the chair was in Mr W.’s possession.

**Figure 3. Region of sacral decubitus ulcer on August 11, 2005.**

On the days in which he utilized the chair, Mr W. generated an average of 212 minutes (~3.54 hours) of data (Figure 4). He spent about half of this time (127 minutes) leaning back in the chair (band “r”). Inspection of the data revealed that on each day that he tipped back, he also stood (bands 5-25). On these days, he stood an average of 97 minutes (1.6 hours) in the target band (20 degrees).

**Figure 4. Time-based utilization of the standing wheelchair: April thru August**

**Conclusions**

Mr W.’s non-healing sacral ulcer resolved after 16 weeks of standing in a standing wheelchair. It is important to note that his general health was gradually improving during this same period. The observed improvements could be attributed to the standing protocol but also to other changes he may have made in his life. Overall, Mr W. was very happy with the standing system, which he continues to use regularly. As an independent quadriplegia, the additional weight of the chair reduced some of Mr W.’s mobility. However, Mr W. gained the healed pressure ulcer and, if given the chair from the start of his SCI, may have then preferred whatever chair he became used to initially. Future studies are addressing the importance of adding stress to paralyzed limbs before they lose bone density.