Original article

Improvement of Walking Functions in Stroke-induced Hemiplegic Patients who Used a Robotic Rehab Instrument

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Abstract

Background: Patients who have developed walking difficulties due to cerebrovascular attack (CVA)-induced hemiplegia or other causes require being treated with effective procedures.

Objectives: This report's purpose is to introduce the effectiveness of a robotic rehab device developed by Honda Motor Co. called the Honda Assist® in improving such patients' walking functions.

Patients and Methods: Thirty-one patients who developed walking difficulties due to CVA-associated hemiplegia (n=21) or other causes (n=10) were studied. Four parameters were used for evaluation; (1) Time needed to walk down 10 meters, (2) Average measure of a stride, (3) Average of steps taken per minute, (4) Degrees of symmetry between what Honda defines as "right scissors' angle" and "left scissors' angle," namely the angles formed by the femurs of a walking person's right and left legs on the sagittal plane.

Results: The study showed the device exerted statistically significant effects in improving the 31's functions in terms of (1), (2) and (4). What was especially noteworthy was its ability to raise the above-mentioned degree of symmetry in general. But it did not cause a statistically significant change in the measure of such symmetry at eight of the 31 at which more than three years have elapsed since the outbreak of such hemiplegia.

We concluded it improved the cohort's walking functions. Furthermore, we noted some of the patients, heartened at the improved functions, have shown positive changes in both the quality of their inter-personal activities and willingness to play a more active part in their community's activities.

Introduction

A burgeoning number of geriatric patients who have developed walking difficulties due to cerebrovascular attack-induced hemiplegia or other causes require being treated with effective procedures to facilitate the rehabilitation of their walking functions. Recently, we have developed several procedures to restore or improve the walking functions of these patients by using a robotic rehab instrument called the Honda Assist®, a walking assist device which incorporates Honda Motor Co.'s sophisticated humanoid robot technology.

This instrument is a compact, lightweight programmable gadget to be fastened with three belts around the patients' waist and thighs, which our study showed helped many of our patients revive the ability to walk steadily, also with the aid of our carefully designed rehabilitation training programs. This report's purpose is to introduce the effectiveness of this robotic rehab system in improving the walking functions of a growing populace of patients worldwide who are suffering from cerebrovascular attack-induced hemiplegia or walking difficulties stemming from other causes.

Methods

A total of 31 patients (n=31) who had developed various degrees of walking difficulties as a result of cerebrovascular attack-induced hemiplegia (n=21) or due to other causes such as fractured bones (n=3), Parkinson's disease (n=2), rheumatism (n=2), cognitive impairment (n=2) and the ossification of posterior longitudinal ligament (n=1) were trained by our team of physical therapists and doctors who applied to them the Honda Assist ® (Figure 1,2) one or two days each week for a trial period lasting for two months. （Figure 3）

Fig. 1. Honda Assist ® (Rear View)

Fig. 2. Honda Assist ® Fastened to body with belts(Side View)

Fig. 3. Honda Assist ® (Rehab staff explaining data measured with controller wirelessly connected with Honda Assist ®)

Four parameters used by the team to evaluate the robotic device's effectiveness in improving the patients' walking functions were as follows:

1. Time needed to walk down 10 meters
2. Average measure of a stride
3. Average number of steps taken per minute
4. Degrees of symmetry (degrees of closeness) between the measures of what Honda Motor defines as "right scissors' angle" and "left scissors' angle" formed by the centerlines of the patients' right and left femurs with their hip joints being the points where the centerlines cross.

The measures of the angles formed by the middle lines of the femurs were wirelessly transmitted to, and logged in, a controller's memory device with sensors mounted in the two motors fastened to the patients' hip joints (roughly above their greater trochanters), which provide torque to their legs via the belts wrapped around their thighs. Patients' walking performances were measured at the two-month rehab period's onset and close after the robotic assist was switched off.

This study was approved by the Ethics Committee of Medical corporation Jinsenkai.

Table 1. Changes in Parameters to Gauge the Soundness of Walking before and after Honda Assist-backed Rehab

	With Honda Assist			Without Honda Assist		
	Before Training	After Training	p value	Before Training	After Training	p value
Time to walk 10 m (sec.)	44.9	32.5	p<0.05	47.6	45.1	p=0.37
Average stride (cm)	28.4	31.8	p<0.05	29.5	31.2	p=0.12
Average steps in 1 min.	70.6	78.9	p=0.15	77.7	72.3	p=0.33
Scissors' angle ratio	0.66	0.74	p<0.05	0.57	0.64	p=0.15

(See appendix for calculation formulae)

Appendix to Table 1

Mathematical Formulae used in Computing Degrees of Symmetry between "Right Scissors' Angle" (A) and "Left Scissors' Angle" (B)

Condition	Formula for computing	Criteria to determine which formula should be used to calculate degrees of symmetry between right scissors' angle and left scissors' angles
A>B	B/A	Formula used in cases where right leg's walking function is superior to paralyzed left leg's
A=B	1	In cases where angles formed by right and left legs are the same disregards of whichever foot is swung forward to the widest angle from the perpendicular drawn from a person's hip joint to the ground
A<B	A/B	Formula used in cases where left leg's walking function is superior to paralyzed right leg's

Results

Table 1 shows the results of the two-month rehab training for two cohorts of patients who used or did not use the Honda Assist. The cohort that did not use the assist numbered 12, including eight geriatric patients who developed hemiplegia due to cerebrovascular attacks. The four types of parameters were measured at the onset and the close of the rehab period.

Discussion

The rehabilitation of patients with the history of cerebrovascular attacks is a time-consuming process, which oftentimes turns out to be painful for patients and their families because of the inadequate effectiveness of conventional rehabilitation programs. We have examined the effectiveness of the Honda Assist®, a hip sensors-fitted robotic gadget incorporating Honda Motor's humanoid robot technology and lithium ion battery-powered compact motors that provide torque to help patients flex or extend their legs' muscles.

The present study's results have proved that the assist, when backed by carefully designed rehab programs, has clearly resulted in the improvements of the walking functions of the hemiplegic patients who have been afflicted by various episodes of cerebrovascular diseases.

Fastening this device to patients did not take much time because of its lightweight and ease-of-fitting features. Geriatric patients were able to wear this instrument easily and speedily with the aid of rehab staffs. It is presently unknown whether this instrument's effects in improving their walking functions will last permanently or only temporarily. However, most of the patients who experienced the positive effects of this instrument expressed desires to continue their rehabilitation programs using this robotic system.

The results of the present study showed that the positive effects of this walk assist were especially noteworthy with regards to clear increases in the degrees of symmetry between the measures of "right scissors angle" and "left scissors angle" formed by the centerlines of the patients' right and left femurs with their right and left hip joints being the points where the two centerlines cross.

Furthermore, patients at which more than 5 years have passed since their cerebrovascular attacks did not show significant improvements in walking functions even when this gadget was used. Patients at which more than three years have elapsed after the outbreak of their cerebrovascular attacks did not show improvements in terms of degrees of symmetry between their right and left scissors' angles. However, the speed of walking increased even at these patients thanks to the robotic assist.

Conclusion

We have concluded that this gadget did exert the positive effects of improving the walking functions in the degrees of symmetry at the hip-joint angles as defined by Honda at the above-mentioned cohort of hemipelagic patients who underwent cerebrovascular attacks. Furthermore, we have noted that some of the patients who used this robotic assist, apparently heartened at the improvements of their walking functions, have shown positive changes in both the quality of their inter-personal activities and the willingness to play a more active part in their community's activities.

The author and co-authors do not have any conflict of interest to disclose regarding this academic paper.

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