A case of post-stroke right hemiplegic patient

Now, let us report our findings on the case of the 73-year-old male to whom we referred in the abstract. He suffered an atherosclerosis, one of humans' stroke causes, at his left cerebral hemisphere in October, 2017 -- seven months prior to the first of the two measurement sessions we performed with the Honda Walking Assist (HWA). The resultant data from the two measurement sessions are presented in the subsequent pages of this paper.

His walking performances, RSAs and LSAs were measured on May 17, 2018, and on October 8, 2019. These measurements were performed in two manners – with therapists letting the HWA apply, and refraining from letting it apply, a torque to his thighs.

When he suffered the stroke and resultant right hemiplegia, he came to reply on a wheelchair. When he was first brought to our rehabilitation center on December 28, 2017, he was in a wheelchair. Although he developed a right hemiplegia, he did neither develop a dementia nor any symptom of executive cerebral dysfunctions. He lives at his home, rather than needing to live in our nursing-care facility collectively with other elderly patients.

We began to apply the HWA to his rehabilitation on May 17, 2018, the day of his first measurement. We applied a 16-month rehabilitation training to him on the basis of the HWA by the day of his second data measurement on October 8, 2019.

Because his walking ability have been greatly improved with the aid of the HWA, he can now walk simply by using a cane without having to remain in a wheelchair or needing to rely on the HWA. Because his walking ability has been greatly improved by the HWA, he recently went out to enjoy watching his female grandchild's soccer game to cheer her school team.

The characteristics of his walking pattern, the measures of the two types of scissors angles (LSAs and RSAs) and the results of right-left symmetry degree calculation performed with the above formula are shown in the subsequent six pages, alongside with the photographs of the patient, one of his therapists and

three of his rehabilitation training sessions. We hid his face portion on the photos to hide his identity. Since he had the stroke at the left hemisphere of his brain, he became hemiplegic at the right side of his body. Readers can confirm this fact from the photos of the rehabilitation sessions.

When we first measured his LSA, RSA and the degree of left-right symmetry on May 17, 2018, without letting the HWA apply any quantity of torque (forward-and-backward swinging force) to his thighs via its two thigh frames, his LSA and RSA came to 28.5 degrees and 12.2 degrees, causing his degree of left-right symmetry to come to 0.43. On the same day, when we measured his LSA, RSA and the degree of left-right symmetry by getting the HWA to apply a mild torque to his thighs, the three readings improved to 38.0 degrees, 19.8 degrees and 0.52. The HWA applied a torque of 2.0 newton-metres to both his left and right legs to help them flex and extend his legs.

On October 8, 2019, we measured anew his LSA, RSA and the degree of left-right symmetry, after providing him with a 16-month HWA-based rehabilitation training at the frequency of twice a week. We did so in two manners – without letting the HWA apply a torque to his thighs and then by getting it to impart a torque to the thighs.

When we -- firstly on that day -- measured his LSA, RSA and degree of left-right symmetry without letting it apply a torque, his LSA, RSA and the degree of symmetry came to 35.5 degrees, 22.6 degrees and 0.64, attesting to the strong rehabilitation effects which the HWA can produce to improve the walking ability of post-stroke hemiplegic patients who received HWA-based rehabilitation training for several months.

We performed a separate measurement of his LSA, RSA and degree of symmetry on the same day by getting the HWA to impart a torque to his thighs. Resultant readings came to 41.3 degrees, 28.7 degrees and 0.69 for the LSA, RSA and the degree of symmetry. In this second measurement of the day, we had the HWA impart a torque of 1.1 N-m to his left thigh to help it flex the thigh, while getting it to impart a torque of 1.4 N-m to his right thigh to help it flex the thigh.

As for torque values which we let the HWA give to the patient to help him extend his left and right legs, the torque figures stood at 1.4 N-m for the left thigh and 1.1 N-m for the right thigh.

What is the most noteworthy fact signified by these readings obtained on May 17, 2018 and then on October 8, 2019 is the fact that the degree of his left-right symmetry improved sharply from 0.43 to 0.64 even when we did not let the HWA apply any quantity of torque to his thighs.

The fact makes evidence of the HWA's strong ability to rehabilitate the walking ability of post-stroke hemiplegic patients.

The right-left symmetry degree calculation was conducted in accordance with the third of the three formulae of Table 1 of Page 127. Consequently, we divided his RSA readings with his LSA readings in line with the table 1 rules. In this manner, we obtained the left-right symmetry value of 0.43 for May 17, 2018 and then the corresponding value of 0.64 on October 8, 2019 even when we did not let the HWA apply any quantity of torque to his thighs.

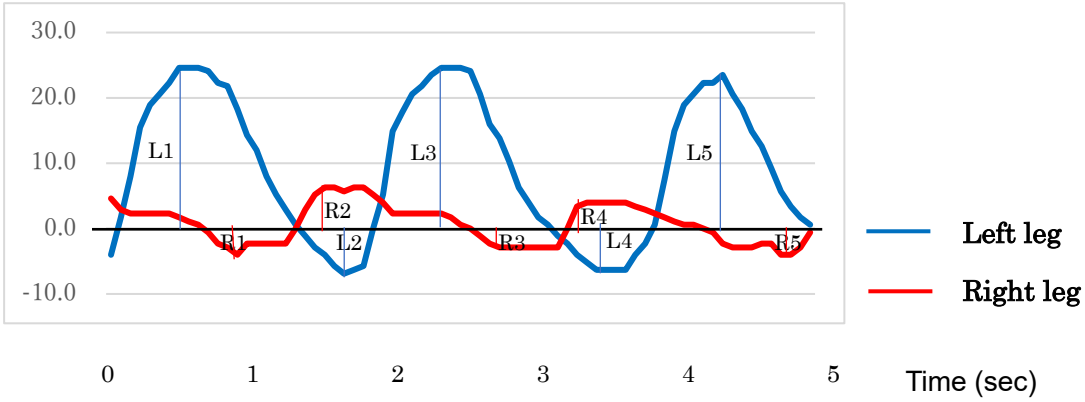
This change in the symmetry degree readings after the 16-month rehabilitation period signifies a remarkable improvement in his walking ability, so this finding should give hope to doctors and therapists engaging in similar rehabilitation efforts for post-stroke hemiplegic patients around the world.

Because the patient was hemiplegic at his right side, his LSA readings were larger than his RSA readings. On all occasions of measurements, he used a cane to supplement his decreased walking functions. This case also makes evidence of the fact that the numerical expression of humans' gait ability which are enabled by the HWA is an excellent way of measuring and quantifying their walking ability.

Subsequent examinations of this and other patients with the aid of the HWA and other types of rehabilitation apparatus will be informative. Further examinations which we plan to conduct will show what rehabilitation instruments are effective or even is the most effective in rehabilitating post-stroke hemiplegic patients' walking ability.

Figure 6. Hemiplegic patient's Walking Pattern measured by the HWA (when he walked with the aid of a cane)
Without letting the HWA apply a Torque to his thighs **(2018/5/17)**

Changes in the angle made with each femur measured with the passage of time
Angle (°)



L1(24.6)	R2(6.3)	L3(24.6)	R4(4.0)	L5(23.5)
R1(-4.0)	L2(-6.9)	R3(-2.9)	L4(-7.4)	R5(-4.0)

$$\text{Left Scissors Angle} = \frac{(L1-R1)+(L3-R3)+(L5-R5)}{3} = 28.5$$

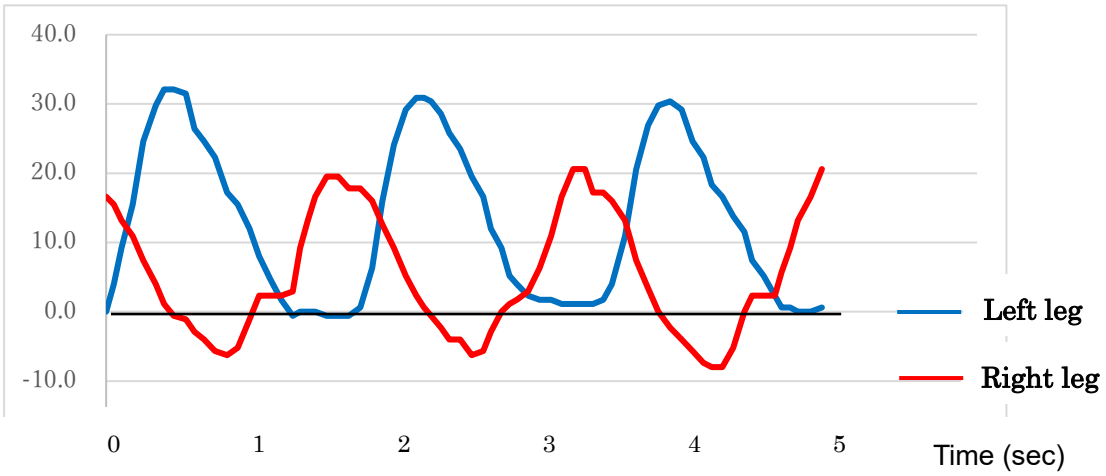
$$\text{Right Scissors Angle} = \frac{(R2-L2)+(R4-L4)}{2} = 12.2$$

Ratio R/L 12.2/28.5= 0.43

Figure 7. Hemiplegic patient's walking pattern measured while letting the HWA apply a *Torque to his thighs* (2018/5/17)

Torque applieded

	Left	Right
Flexion	2.0 Nm	2.0 Nm
Extension	2.0 Nm	2.0 Nm



L1(32.1)	R2(19.5)	L3(30.9)	R4(20.6)	L5(30.4)
R1(-6.3)	L2(-0.6)	R3(-6.3)	L4(1.1)	R5(-8.0)

$$\text{Left Scissors Angle} = \frac{(L1-R1)+(L3-R3)+(L5-R5)}{3} = 38.0$$

$$\text{Right Scissor Angle} = \frac{(R2-L2)+(R4-L4)}{2} = 19.8$$

Ratio R/L 19.8/38.0= 0.52

Figure 8. Pictures of the case subjected to this study
73-year-old, post-stroke, right hemiplegic male (pictures taken on 2018/4/24)

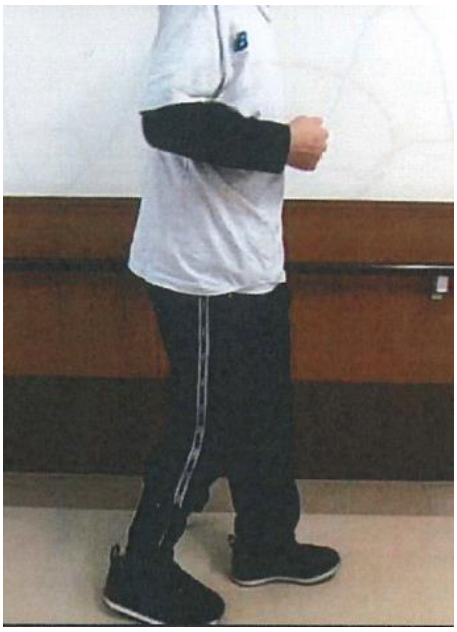
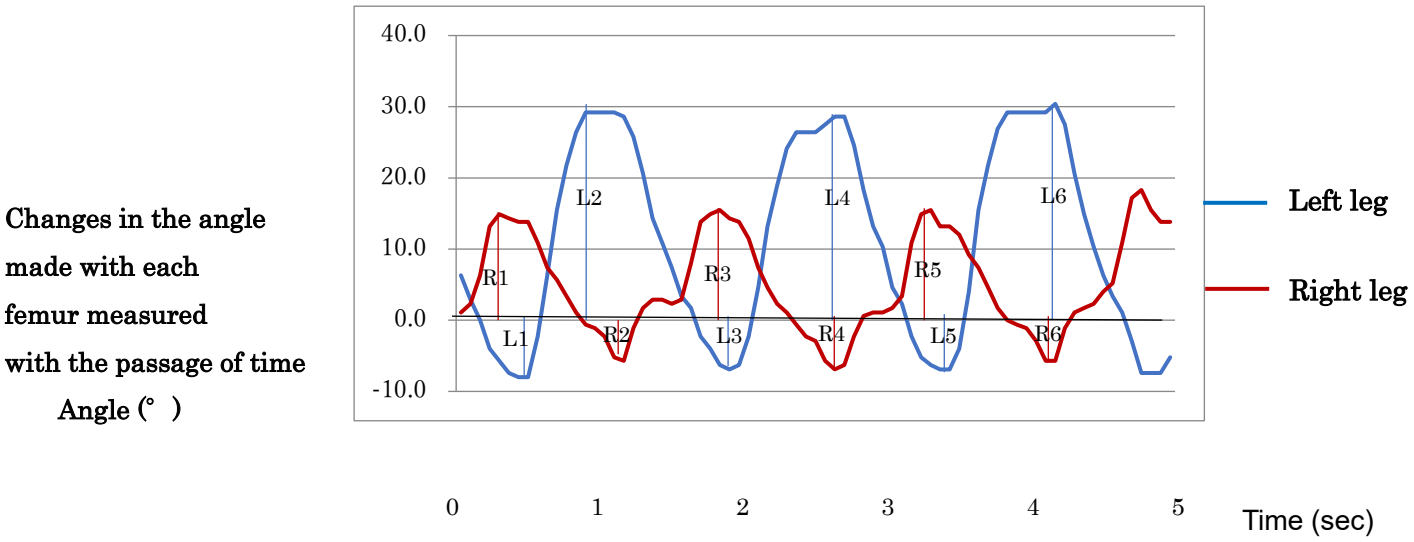


Figure 9. Hemiplegic patient's walking pattern measured when we refrained from letting the HWA apply a *Torque to his thighs* (2019/10/8)



R1(14.9)	R2(-5.7)	R3(15.5)	R4(-6.9)	R5(15.5)	R6(-5.7)
L1(-8.0)	L2(29.2)	L3(-6.9)	L4(28.6)	L5(-6.9)	L6(30.4)

$$\text{Left Scissors Angle} = \frac{(L2-R2) + (L4-R4) + (L6-R6)}{3} = 35.5$$

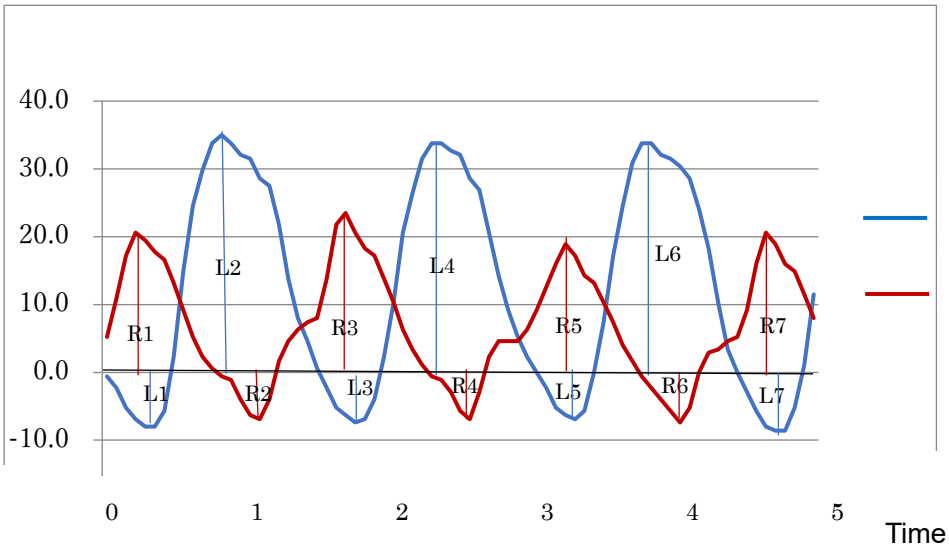
$$\text{Right Scissors Angle} = \frac{(R1-L1) + (R3-L3) + (R5-L5)}{3} = 22.6$$

Ratio R/L 22.6/35.5= 0.64

Figure 10. Hemiplegic patient's Walking Pattern measured when we got the HWA to apply a *Torque to his thighs* (2019/10/8)

Torque applied

	Left	Right
Flexion	1.1 Nm	1.4 Nm
Extension	1.4 Nm	1.1 Nm



R1(20.9)	R2(-6.9)	R3(23.5)	R4(-6.9)	R5(18.9)	R6(-7.4)	R7(20.6)
L1(-8.0)	L2(35.0)	L3(-7.4)	L4(33.8)	L5(-6.9)	L6(33.8)	L7(-8.6)

$$\text{Left Scissors Angle} = \frac{(L2-R2)+(L4-R4)+(L6-R6)}{3} = 41.3$$

$$\text{Right Scissors Angle} = \frac{(R1-L1)+(R3-L3)+(R5-L5)+(R6-L6)}{4} = 28.7$$

Ratio R/L 28.7/41.3=0.69

Figure 11. Pictures of the case subjected to this study
73-year-old, post-stroke, right hemiplegic male
(pictures taken on 2019/10/8)