講演番号 195

文献番号 20225195

A Study on Reduction of Walking Load by Traction using Electric Wheelchair

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KEY WORDS:**other means of mobility, personal mobility, elderly person,** Wheelchair, Walking load [F3]

In order to maintain the health of the elderly, it is important to provide them with opportunities to walk. We are developing a walking-assist electric wheelchair with an automatic running function to serve as a walking partner. In this study, we investigated the effect of traction by the electric wheelchair on walking through experiments. A simple mechanical model was also used to analyze and discuss the effects of traction.

As shown in Fig. 1, a handle was attached to the back of the wheelchair (Whill Model CR), and a force gauge was attached to the handle. There were four subjects in the experiments. Walking load was measured with an arm-worn heart rate monitor (POLAR OH1+). The condition without traction force is called normal walking, and the condition with traction force is called assisted walking. In both conditions, the walking speed was about 6 km/h, and the heart rate was compared by walking up the uphill slope of about 6%.

Figure 2 plots the heart rate increments averaged every 10 seconds from the beginning of the walk for the four subjects during two normal walking sessions and two assisted walking sessions. In the normal walking, the heart rate continued to increase until near the top of the hill, but in the assisted walking, the increase was relatively small and the heart rate was almost constant. The subjective evaluation showed that all four subjects found the assisted walking easier than the normal walking.

Next, the walking on a slope was analyzed by describing the motion of one leg from ground contact to landing using an inverted pendulum model. Figure 3 shows the calculation model. The body weight m=60[kg], the leg length l=0.8[m], and the stride opening angle of each step is $-\theta_0$ to $+\theta_0$=+30[rad]. The slope of the hill was α=0.1[rad], and the traction force during assisted walking was fh=70[N].

The results of the calculations with and without traction force for uphill walking are shown in Figure 4. It was confirmed that when there was no traction, a small braking force and a large kicking force were required. Furthermore, when traction was applied, the kicking force decreased and balanced with the braking force. This is thought to be the reason why the heart rate does not increase when traction is applied on the uphill slope, as the walking load decreases and walking becomes easier.

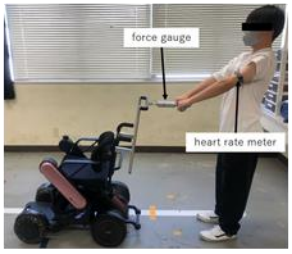

Fig.1 Measuring Instruments

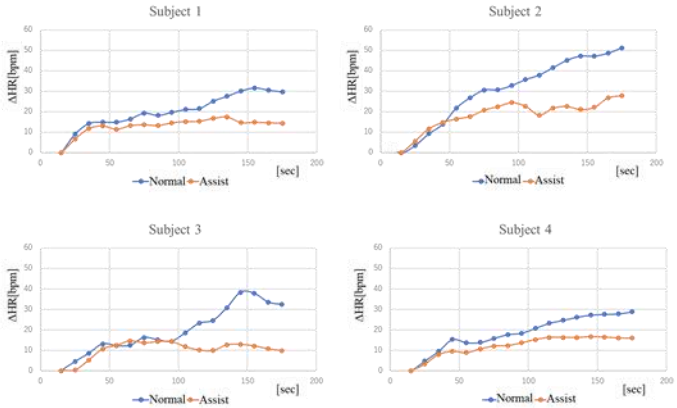

Fig.2 Heart Rate Increments during Uphill Walking

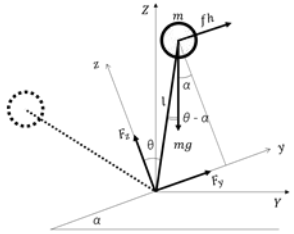

Fig.3 Inverted Pendulum Model for Gait Analysis

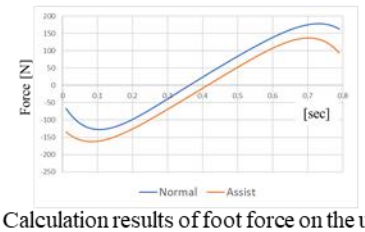

Fig.4 Calculation results of foot force on the uphill slope