A example of frequency analysis of change in acceleration in body under walking

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Abstract

For an objective evaluation of the effect of anti-slip on the road in the winter. The change in the acceleration in the body under walking was investigated. The results of obtaining is as follows. The acceleration of the leg changes greatly by slipping. When the slip of several steps is caused, the frequency element which corresponds to the cadence has decreased to 68.8%.

Key words : Biomechanics, Gait, Cold Region, Frozen Road Surface, Slip, Acceleration, Anti-Slip Device, Evaluate Method, Frequency Analysis, Spectrum.

Introduction

Recently, the accident of the pedestrian's slipping and falling has increased in frozen road in the cold region. Especially, the fall leads easily to the fracture for an aged person . And, it is likely to be hospitalized, and to become bedridden. Moreover, mentally and physically handicapped person might invite a new trouble by the impact by the fall. Therefore, some measures are necessary for the decrease of insurance money, for the reduction of the medical treatment expense, and for promotion of the resident health.

To prevent the slip fall in walking on the road in winter, the anti-slip road is actively developed, improvement of method of removing ice and snow from road, and the improvement of the anti-slip performance of the out sole of shoe etc, are also the same. The surface of contact of the road and the out sole of shoe is various. Therefore, the slipperiness under walking cannot be indicated by one coefficient of friction. Then, we want to find the possibility of the establishment of an objective evaluation method in the effect of anti-slip . The acceleration change of the leg and the abdomen under walking is measured for that. The acceleration was measured in the crossing pavement on Sapporo city in Japan. The road situations of the two crossing pavements were different respectively.

Measurement method

Measurement system

To measure the acceleration of the body in the direction where it progressed to be walking,

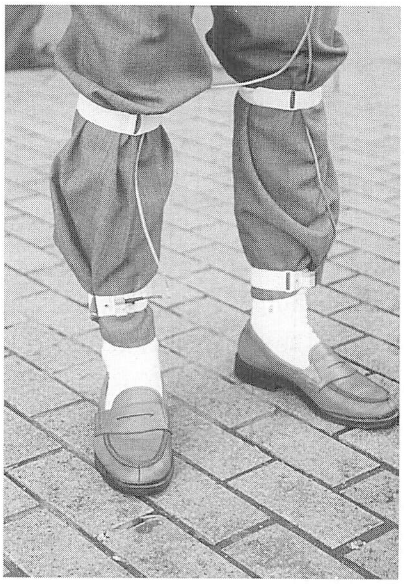

Photo. 1 Installation situation of Leg Sensor

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the acceleration sensor was installed in the leg and the abdomen(Body center). The leg sensor was installed in the upper part of foot joint forward of the leg. Photo. 1 shows the installation situation of the leg sensor. Moreover, the acceleration of each 30ms was recorded while walking.

The testee is carrying the amplifier and logger while measuring the acceleration. Photo. 2 shows the installation situation of the abdomen sensor and the amplifier. Afterwards, the acceleration data is forwarded to the computer by RS-232C interface. And, the acceleration data is analyzed with the computer.

Testee and walking method

The testee is a man of 41 years old, and it is the people who do not have the body trouble. And, the appearance that the testee walks is usual. The walking load is not peculiar either. The testee walked usually by the cadence of 120 steps/minute. The testee walked with a metronome aiming to keep the cadence to be constant. Shoes used for the measurement are general gentleman shoes for the winter. The out sole of shoe is made from rubber by which straw is mixed . And the shoes are the one with high effect of anti-slip.

Walking road

The testee walked from the south to the north in the crossing pavement in Sapporo City. The crossing pavement is in WEST 3 and WEST 4 of the SOUTH 4. The length of the crossing pavement is about 31m including the central separation belt. The testee finishes walking about 52 steps (one foot 26 steps) when pedestrian's step length is assumed to be 60cm. Moreover, walking is finished at about 30 seconds when the cadence is assumed to be 120 steps/minute.

The crossing pavement in WEST 3 was cleared well, and the surface of the road was in there was no ice and snow in the state of moist. Photo. 3 shows the crossing pavement without ice and snow. On the other hand, the crossing pavement in WEST 4 was frozen the surface in

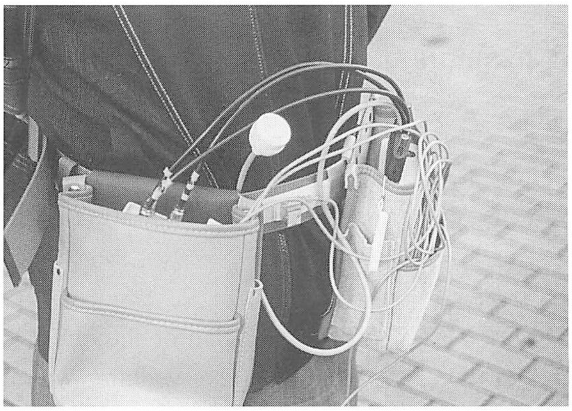

Photo. 2　Installation situation of Abdomen Sensor, Amplifier and Data Logger

Photo. 3　Crossing pavement without ice and snow in WEST 3 (*Wet* condition)

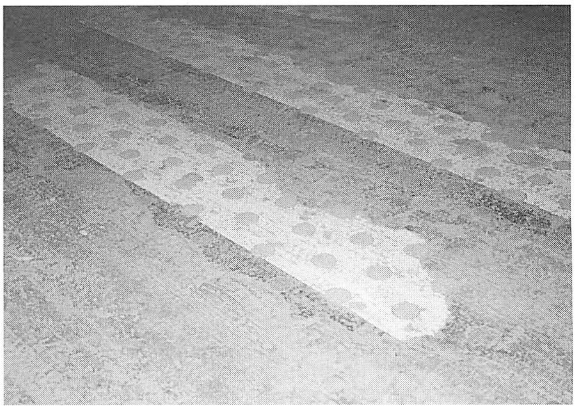

Photo.4　Crossing pavement covered with ice and snow in WEST 4 (*Icy* condition)

the edge and the vicinity of the central separation belt . And, the whole is covered with a powdered snow. Photo. 4 shows the crossing pavement covered with ice and snow.

Result and consideration

Walking feeling

When walking on the road without ice and snow, the slip was not caused. On the other hand, the testee slipped several times in the crossing pavement which had been covered with the ice and snow of WEST 4. The testee felt as it was not easy to walk. The foot slipped backward at the toe off . And, the foot slipped forward at the heel contact . However, the testee walked so as not to fall.

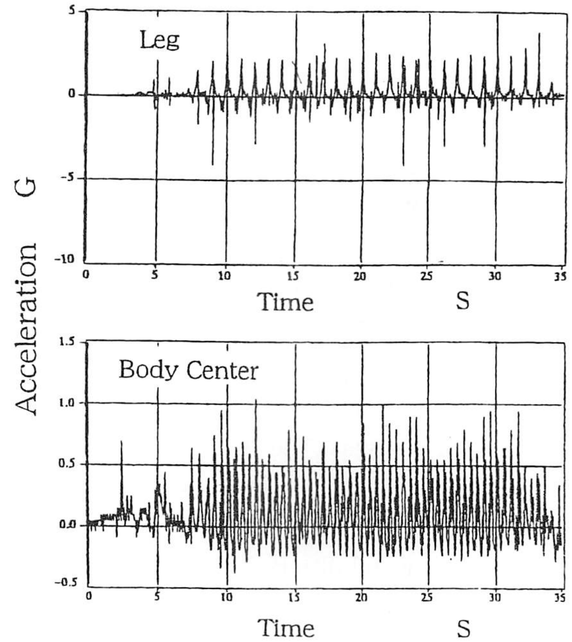

Fig. 1 **Acceleration during gait on *Wet* condition**

Acceleration wave

Fig. 1 shows the acceleration wave when there is no slip. In general, the acceleration of the body changes greatly when the slip is caused. However, the acceleration of Fig. 1 has changed by ± 4G in the leg and abdomen within the range of ± 1G. From the influence of both right and left legs, the acceleration of the abdomen has changed by the frequency twice of the leg.

Fig. 2 shows the acceleration wave when walking in the crossing pavement covered with ice and snow. When Fig. 2 was compared with Fig. 1, the difference was not able to be confirmed to the shape of waves in the abdomen. However, the acceleration of the leg indicated a big value five times. The acceleration caused by the slip became 8G.

In this case, when having walked 24 steps, it was understood to have caused the slip by five steps.

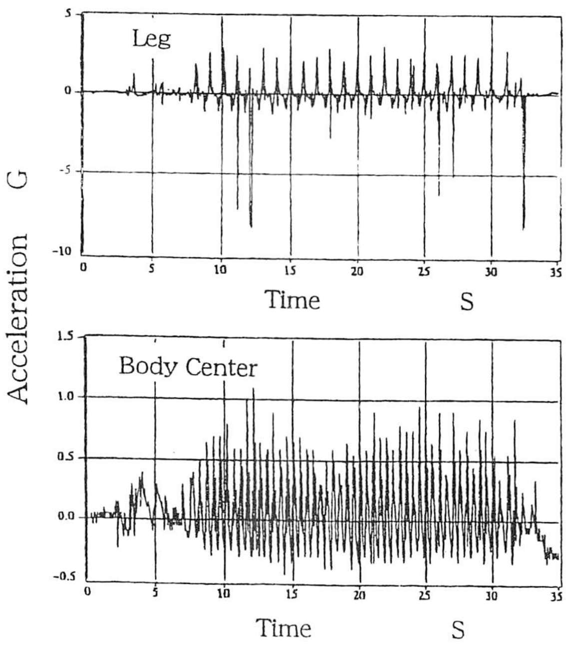

Fig. 2 **Acceleration during gait on *Icy* condition**

Frequency analysis of acceleration

Fig. 3 and Fig. 4 showed the frequency spectrum of the acceleration of Fig. 1 and Fig. 2. One Hz element of the acceleration of a left leg was 0.48 because the cadence was 120 steps/minute, and the 1Hz elements were the largest. And, it was large in the order of 0.5Hz and 2Hz following 1Hz element. On the other hand, when several-time slips were caused, 1Hz element became 0.33.

It will have decreased to 68.8%. Therefore, the change in the frequency element of the acceleration which corresponds to the cadence can be numerical value displayed. The numerical value has the possibility to be used to evaluate the effect of anti-slip.

When the frequency spectrum of the acceleration of the abdomen was observed, 2Hz element of it was the largest because the movement of both legs influenced the movement of the abdomen. However, the difference was not admitted in the magnitude of main 2Hz elements in the frequency spectrum of the acceleration of the abdomen when walking on a different road. On the other hand, when the slip was generated, some elements were large in a high frequency range.

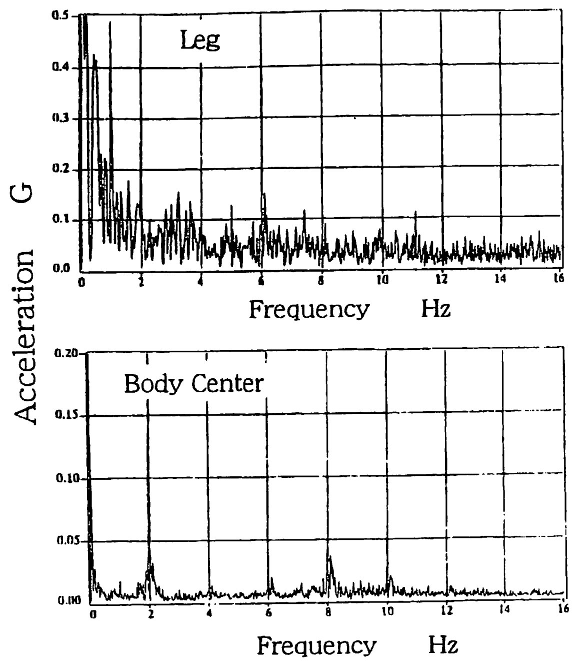

Fig. 3 Spectrum of acceleration during gait on *Wet* condition

Conclusion

The testee walked in two crossing pavement where the road situation was different. The frequency analysis of the acceleration on the leg and abdomen of the testee was done.

When several time slips are caused, the acceleration of the leg has decreased up to 68.8% in main frequency element.

In this measurement, a big difference was not admitted about the acceleration of the abdomen.

Acknowledgement

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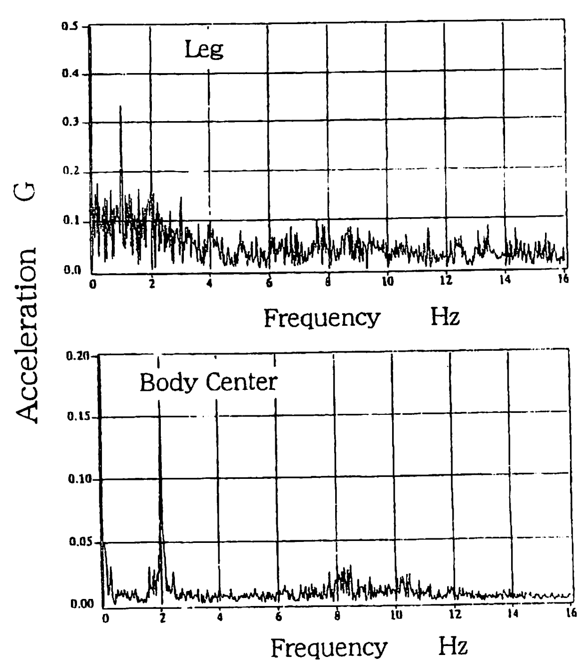

Fig. 4 Spectrum of acceleration during gait on *Icy* condition