Dynamic Measurement of Body Swing in Jog Training

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Abstract: To know load unbalance of body is an important concern for us to keep our physical health. The measurement of load unbalance of human body standing at a point is well known. But, on the other hand, it is more important to know the load unbalance in daily life. This paper describes the system and method to measure load unbalance of human body to left or right side in jogging. The load unbalance is estimated by an inclination angle of body. The inclination angle is calculated by acceleration information from acceleration sensor attached on waist. As the measurement system is constructed as a portable and wearable unit, it is used indoor and outdoor.

Keywords: acceleration sensor; inclination of body; jogging; portable and wearable unit; Body Area Network.

1. INTRODUCTION

Body in jogging is swinging on left-right direction. And, the swing is increased according to time transition. The large body swing becomes the cause of heavy load and strong pain at a hip joint and a knee. So runners need to know the status of the swing of the body while jogging. But, runner doesn’t notice an increase in body swing. In addition, it cannot be determined visually. It is necessary to measure and inform the swing of the body in jogging. This paper says about that the acceleration sensor on the waist detect swing of the body in jogging.

2. CONSTRUCTION OF MEASURING DEVICE

Fig. 1 shows construction of BAN (Body Area Network) system. The main function of the system is acquisition, process, management, and storage. This system consists of 4 portions of Shoulder, Wrist, Waist, and Ankle. The interconnection between modules is made by BAN. Data collected by each part of the body is brought together in the module of the waist, and it feeds back to the person who wearing BAN with a voice advice. If he has the health problem, system sends data to his family or doctor using cell phone.

This time, body swing is measured using waist module, and shoulder module. The measuring device is constructed by 3-axis acceleration sensor. Fig. 2 shows the device attached on the waist of human body. Y axis of acceleration is horizontal (right-left) of body. X axis is vertical (up-down). And Z axis is the direction to front-back of body. In this study, the body swing in jog training has been measured by using acceleration data of Y axis. Fig. 3 shows system construction. Acceleration data go to dsPIC33FJ. Audio Module sends advice with a voice. Final data save to Micro SD Card. The body swing in jogging is by the standard deviation of acceleration. The smaller standard deviation is the smaller body swing. Big standard deviation is big body swing. The standard deviation is calculated by the acceleration data for 20 seconds. The smaller body swing is good in jogging. That is, the smaller the standard deviation is good.

### Table 1 Acceleration sensor spec.

<table>
<thead>
<tr>
<th>PARAMETERS</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range</td>
<td>±2G</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>660mV/G</td>
</tr>
<tr>
<td>0G Offset</td>
<td>1.65V</td>
</tr>
<tr>
<td>Power Supply</td>
<td>2.7V to 5.5V</td>
</tr>
</tbody>
</table>

Fig. 1 Construct of Body Area Network system.

Fig. 2 State of mounting.
3. EVALUATION OF BODY SWING

3.1 Experimental Method

The subjects jog for 30 minutes, to observe changes in the standard deviation of 30 minutes. This experiment will use the treadmill. Jog speed is 8 km/h. This speed is general jogging pace. The subjects are A, B, C in Table 2. The subject answers the questionnaire of the level of tiredness (5 steps) to every five minutes. “1” means that there is afford to run. “5” means that it is running into limits.

<table>
<thead>
<tr>
<th>Name</th>
<th>Age</th>
<th>Sex</th>
<th>Height(cm)</th>
<th>Weight(kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>24</td>
<td>Male</td>
<td>170</td>
<td>52</td>
</tr>
<tr>
<td>B</td>
<td>23</td>
<td>Male</td>
<td>167</td>
<td>50</td>
</tr>
<tr>
<td>C</td>
<td>22</td>
<td>Male</td>
<td>170</td>
<td>68</td>
</tr>
<tr>
<td>D</td>
<td>24</td>
<td>Male</td>
<td>172</td>
<td>67</td>
</tr>
<tr>
<td>E</td>
<td>21</td>
<td>Male</td>
<td>171</td>
<td>63</td>
</tr>
<tr>
<td>F</td>
<td>22</td>
<td>Male</td>
<td>175</td>
<td>75</td>
</tr>
<tr>
<td>G</td>
<td>22</td>
<td>Male</td>
<td>170</td>
<td>56</td>
</tr>
<tr>
<td>H</td>
<td>21</td>
<td>Male</td>
<td>178</td>
<td>61</td>
</tr>
</tbody>
</table>

3.2 Experimental Result

Figs. 5–7 shows standard deviation in 30 minutes. Blue line is the standard deviation (mG). It is clear that an increased standard deviation in 30 minutes. The body swing increases in jogging were observed.

Figs. 8–13 are figures that are cast a spotlight on each 5 minutes (Subject A) to display in detail. Blue line is the standard deviation (mG). Red line is the approximation straight line of standard deviation. Figs. 8–13 show that the first 5 minutes has a large change of the approximation.
Compared these values of each section. Figs. 14~19 shows average standard deviation, slope and intercept of the approximation straight line of each 6 subjects. Blue block is the average standard deviation, the level of tiredness. Red line is slope, and green line is intercept of approximation straight line. Yellow triangle on graph is the level of tiredness. This result shows some things. The body swing and the level of tiredness are related. And subject is categorized into three types.
Table 3 shows details of three types. Subject of type 1 has not exercised usually. Subject of type 2 and type 3 has exercised usually.

<table>
<thead>
<tr>
<th>Type</th>
<th>Type1</th>
<th>Type2</th>
<th>Type3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject</td>
<td>A, D</td>
<td>B, E</td>
<td>C, F</td>
</tr>
<tr>
<td>Transition of standard deviation</td>
<td>rapidly</td>
<td>stable</td>
<td>stable</td>
</tr>
<tr>
<td>Bias of standard deviation</td>
<td>Low to high</td>
<td>low</td>
<td>high</td>
</tr>
</tbody>
</table>

4. RELATION BETWEEN JOGGING SPEED AND BODY SWING

4.1 Experimental Method

The subject is C, G in Table 2. This experiment will use the treadmill. The subject jogs at the speed of he’s choice. The subject jogs for 4km, to observe changes in the standard deviation of 4km. The subject answers the questionnaire of the level of tiredness (5 steps) to every 1km. “1” means that there is afford to run. “5” means that it is running into limits.

4.2 Experimental Result

Figs. 20, 21 shows standard deviation in 4km. Blue line is the standard deviation. Red line is the threshold of advice. Green line shows advice flowed. Light-blue line is speed of jogging. It is clear that a decreased standard deviation by lower speed. The body swing decreases by lower speed in jogging were observed. But standard deviation increases gradually. This is depended on tiredness.
5. RELATION BETWEEN BODY SWING AND HEART RATE

5.1 Experimental Method

In this experiment, body swing and heart rate are measured using a waist module and a shoulder module to observe relation between the standard deviation and heart rate. The subject is H in Table 2. This experiment will use the treadmill. The subject jogs at the structured speed.

5.2 Experimental Result

Figs. 22, 23 shows standard deviation and heart rate in 20 minutes. Blue line shows the standard deviation. Green line is approximate polynomial of the standard deviation. Purple line is heart rate. Yellow line is approximate polynomial of the heart rate. Speed of jogging is 8km/h (in fig. 22), and 10km/h (in fig. 23).

In fig. 22, heart rate increases in the first 5 minutes, and is stabilized about in 150bpm. In fig. 23, heart rate increases in the first 7 minutes, and is stabilized about in 160bpm. Compared with heart rate of fig. 22, heart rate of fig. 23 is high because of speed of jogging.

In fig. 22, standard deviation is stabilized around 300mG. Standard deviation of fig. 23 increases without being stabilized compared with standard deviation of fig. 22. This result shows that standard deviation is able to stabilize to down speed of jogging.

Exercise in heart rate is 110 ~ 150bpm is called aerobic exercise. Aerobic exercise is good for health. Standard deviation should be stabilized by heart rate keep in 110 ~ 150.
6. CONCLUSIONS

Five conclusions were obtained from the experimental result. The body swing increases in jogging were observed. The body swing and the level of tiredness are related. Subjects are categorized into three types. The body swing decreases by lower speed in jogging were observed. Standard deviation should be stabilized by heart rate keep in 110 ~ 150.

Body unbalance in jogging becomes burden to legs, waist and so on. That is serious problem on a viewpoint of physical health. There are some kinds of the body unbalance which can be self-aware or not. Therefore, the system and method to measure the body unbalance objectively are needed. This system can be detected inclination of body by acceleration information. But, method of inspection is ambiguous. In future, we will measure the inclination of body by ever measure machinery. Should be calculated the correlation between that data and the angle data at the acceleration data. Then we need to get the truth of the angle data at the acceleration. Should be made analysis of measurement data in this system, and found a difference for three types. And should be constructed a fine advice system by using standard deviation and heart rate together.

7. REFERENCES