A STUDY ON CORRELATION BETWEEN PELVIC ROTATION AND RUNNING PERFORMANCE FOR DESIGNING A RUNNING QUALITY INDEX

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Today, there are many people who enjoy jogging in a regular basis. Many of them uses wearable devices to log their running time, route, etc. To improve running performance, it is important to assess running qualitatively as well. However, these devices do not assess quality of running, and do not teach users what to change and how to change in order to improve quality of running. The purpose of this study is to present correlation between pelvic rotation and running performance, experimentally, and discuss how indices can be designed to assess quality of running. For the experiment, 60 student athletes participated and run 1500 meter for two times with an accelerometer and gyro meter sensor attached to their lower back. The result shows that there is a correlation between pelvic rotation and running performance. Followed by discussion for designing the indices of running quality.

KEY WORDS: wearable/portable sensor, pelvic rotation, running quality.

INTRODUCTION: Nowadays, increasing number of people are interested in maintaining good health condition and many of them are enjoying taking a jog on a regular basis. Furthermore, good portion of them are utilizing wearable or portable devices, such as smartphones or smart watches, with embedded sensors to maximize their experiences by logging their activities. The logs, in general, are results of taking advantage of data set from GPS and accelerometer. They provide users with status of running time, distances, route, burned calories, and so on.

However, these status do not tell what to change or/and how to change, in order to improve users' performance of running. This is mainly because that these devices, in general, are limited in measuring body motions while users are running. It would be beneficial for those runners if there is a means to measure body motions during a jog and a way to suggest what to do and how to do for improvement of the performance.

Sensor technology has been used to study walking gait and knee joint angle studies (Kawano, Kobashi, Yagi, Kondo, Yoshiya & Hata, 2007), however, studies of running using portable sensors are relatively sparse (Fong & Chan, 2010). In addition, researches on performance of running with respect to rotational activity of the pelvis is relatively sparse as well (Hamner, Seth & Delp, 2010).

To improve users' running performance, it is needed to assess quality of running, and to designe indices. Therefore, as a first step toward achieving this, we hypothesize that rotational activity of the pelvis around body axis has correlation with running quality. The purpose of this study was to identify whether the hypothesize is correct and examine whether it can be used as a index. This index would be beneficial not only for regular joggers but also for athletes to assess quaily of their running promptly, using portable devices.

METHODS: An experiment was conducted at a University track, measuring time of 1500 meter runs, two times with approximately three hour intervals. There were 60 participants of University student athletes. There were 46 males and 14 females participants. In this experiment, we attached portable wireless sensors (TSND121 by ATR promotion) on where movement of pelvis can be observed, to every participant (Figure 1). Using the sensors, we obtained data set from three axial accelerometers and three axial gyro sensor during the 1500 meter runs.

Figure 1: Sensor used for the experiment (Left), and how it was attached (Right)

RESULTS: Applying PCA to the date set confirmed that the pelvic rotation around Y-axis has dominate information (Figure 2). Obtained data profile with the sensor is shown in Figure 3.
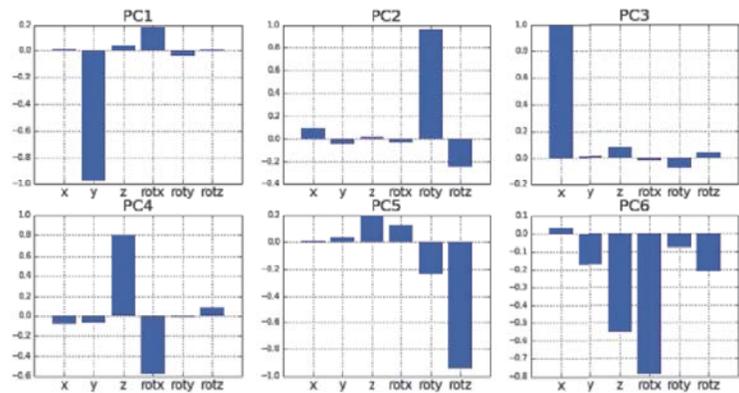
Figure 2: Explained variance ratio of PC1 is 0.4, and PC2 is 0.2. In PC2 the rotation around Y-axis is the main contributor.
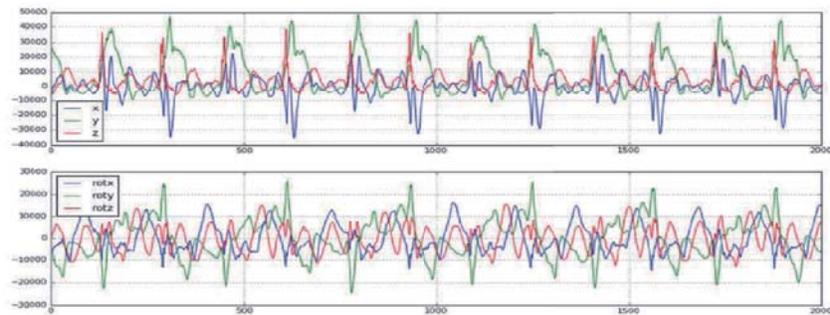
Figure 3: Profile of obtained data. Top is acceleration. Bottom is rotation.
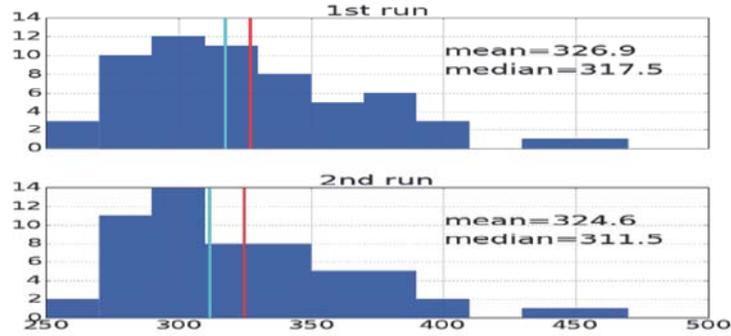
Figure 4: Histogram of 1500m run time. Top is 1st run. Bottom is 2nd run. X-axis is time for 1500m run. The smaller the faster. Y-axis is number of participants. Bin size is 25.

Overall average time of 1st run is 326.9 [s] and median is 317.5 [s]. Overall average of 2nd run is 324.6 [s] and median is 311.5[s] (Figure 4).

To evaluate pelvic rotational activity as A_{RY}, it is formulated as below.

$$A_{RY} = \frac{\sum |R_Y|}{T}$$

, where R_Y [degree/s] is angular velocity at t=i, and T is a duraton of trimed data for analysis which is approximately 200 to 300 [s], (subtract 20 second at both begining and ending from total time), in this paper. It was plotted as Figure 5, where x-axis is A_{RY}, and y-axis is time of 1500 meter run. As it is shown in Figure 5, there is a correlation between the A_{RY} and the 1500 meter run time, with correlation coefficient -0.65.
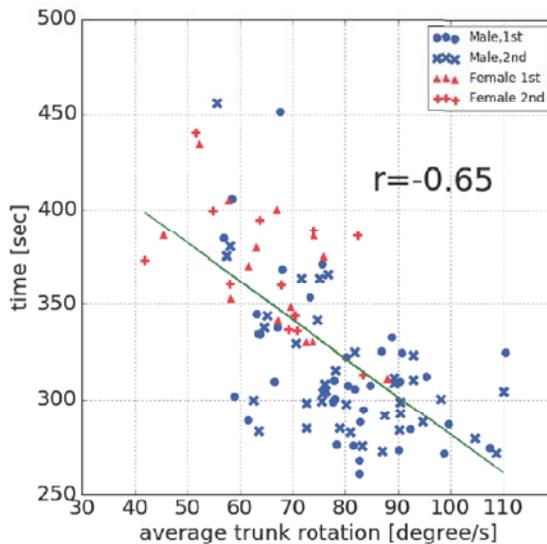
Figure 5: X axis is A_{RY}. Y axis is time of 1500 meter run. There is correlation between the A_{RY} and the time, with correlation coefficient of -0.65.

DISCUSSION: The result indicate that the higher pelvic rotational activity is, the faster one runs. That is, the hypothesis was supported by this experiment. However, to make it to a reliable index of assessing running quality, we need to consider more. For example, considering information of grounding timing of feet and smoothness of rotation of pelvis will
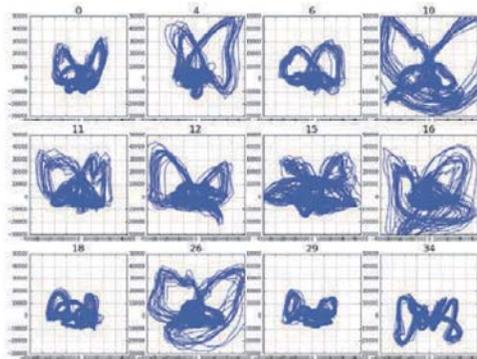
Figure 6: Diagram, horizontal axis being angular velocity around body axis and vertical axis being acceleration in the direction of moving forward/backward. Characteristic of the structures are different from participants.

provide us more information for designing a better index to assess quality of running. It is because that there is structure found when we plot between angular velocity around body axis and acceleration of z-axis, which is the direction of moving forward and backward. The structures differ from participant to participant, even though there seems to be tendency or commonness among those who run fast, and among those who run slow (Figure 6). To tackle this problem, we are planning to apply FFT in order to reduce noise, identify phase shift between pelvic rotation and grounding timing, and to figure out features of different running styles.

CONCLUSION: This study identified that there is a tendency that those who makes more pelvic rotational movement during the 1500-meter running can run faster. This study also shows possibility that using a wearable/portable would enable us to assess quality of running by measuring pelvic movement. With further study, we believe that we can come up with indices that would describe quality of running, in addition to what we have already, such as run time, burn calories, heart rate, and so on. Once the indices are properly designed, we would like to realize a wearable device that can evaluate users' running quality and make suggestions what to change and how to improve running quality by attaching a single portable sensor device on lower back. This would enable a prompt feedback for athletes and coaches.

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