Assessment Of Overall Body Movements During Gait In Patients With Advanced Stage Knee Osteoarthritis Using A Wireless Accelerometer.

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INTRODUCTION: Knee osteoarthritis (KOA) is generally associated with pain and gait disturbance due to joint deformity . Symptoms of KOA are found in 10% of men and 13% of women over the age of 60 years. KOA causes not only pain, but also gait disorders, leading to a decrease in quality of life. Patient-reported outcome measures (PROMs) are routinely used to evaluate the efficacy of KOA treatment. However, PROMs are mainly for evaluation of pain and are insufficient for evaluation of function. On the other hand, quantification of patients' daily behavior is useful for assessing the prognosis and the effect of rehabilitation [Kobsar D: 2015] . The many studies of KOA gait analyses in the past have used root mean square (RMS) scalar values to determine the magnitude of body motion acceleration and the amount of fluctuation. The RMS value is relatively easy to use and appears to be the most constant parameter .Nevertheless, the RMS value may underestimate the true impulse load factor, because it is not necessarily sensitive to large inherent fluctuations .It may be important to evaluate not only the magnitude of RMS scalar values, but also the distribution of acceleration in order to measure the amount of fluctuation in gait. Therefore, evaluation of the distribution of the RMS scalar values in the overall assessment of KOA patients' gait has not been sufficiently investigated at this moment.The purpose of this study was to clarify the characteristics of the entire KOA gait, including the distribution of scalar magnitude and time variability of heel contact using accelerometers.

METHODS: KOA patients and healthy participants wore a 3-axis accelerometer sensor on the third lumbar vertebra. Composite vector (CV) was consisted of synthesizing acceleration data from three axes. In addition to the summation of the CV, a histogram can be created to evaluate in detail the magnitude of the waves. The amount of variation was measured in the longitudinal direction. Variability was evaluated from the distribution of the heel contact duration between both feet measured from the vertical acceleration. The variations of heel contact interval times between KOA patients and healthy subjects were compared from the Poincare plot in Figure 2. In the Poincare plot, the x-axis was set to $PPI_{k,}$ and the y-axis was set to PPI_{k+1}, and the previous and next interval data were plotted as one set. Significant differences between groups were calculated using ANOVA, with a value of $P<0.05$ indicating statistically significant differences for all analyses.

RESULTS: Patient information for healthy subjects and osteoarthritis of the knee, respectively, is presented in Table 1.The knee OA patients had more small accelerations than the healthy subjects, and the accelerations converged to 2-3 $[m/s^2]^2$(Figure1).There was a significant difference between the two groups (ANOVA, $p<0.05$).The variations of heel contact interval times between KOA patients and healthy subjects were compared from the Poincare plot in Figure 2. The Poincare plot (PP_k vs PP_{k+1}) of healthy subjects was distributed near the mean value, but the distribution of KOA patients tended to be widely dispersed (Figure 2). The gray line of this graph means a case that the values of both PP_k and PP_{k+1} were equal. The peak interval data plotted near the gray line may have a high regularity, as in healthy subjects.

DISCUSSION: The knee OA patients had more small accelerations than the healthy subjects, and the accelerations converged to 2-3 $[m/s^2]^2$(Figure1). From the general clinical findings, KOA patients had a limited range of motion of the knee joint and pain avoidance during walking. In addition, KOA patients have a tendency to reduce lower limb movement due to the limited range of motion of the knee joint. The walking movements of KOA patients may be further restricted with this decreased movement of the lower limbs. Figure 1 shows that KOA converges to smaller accelerations, which is thought to be strongly correlated with pain avoidance behavior. The acceleration is the rate of change in velocity per unit time; we thought that it was necessary to analyze the difference in histogram distributions from the fast component to the slow component in order to consider the change in acceleration during gait. The walking intervals of healthy subjects converged around 430 msec, but the values of KOA patients did not converge and showed a tendency to have a large variation, as shown in Figure 2. This may be due to the difference in the time between the interval of heel contact from the affected side to the non-affected side and the interval of heel contact from the non-affected side to the affected side. This change may represent motion to avoid loading on the affected side. KOA patients walked with less overall body movement with limited movable range of knee joint and pain-avoiding motion. The gait of the KOA appeared to be unstable, with high variability in the time interval between peaks.

SIGNIFICANCE/CLINICAL RELEVANCE: This study showed the characteristics of KOA gait, which is an unstable gait with reduced overall body movement and high variability. The results suggest that the gait characteristics of KOA patients can be easily quantified by measurements using a wireless accelerometer.

REFERENCES: Include references here. (References are Optional)

Kobsar D, Osis ST, Hettinga BA, Ferber R. Gait biomechanics and patient-reported function as predictors of response to a hip strengthening exercise intervention in patients with knee osteoarthritis. PLoS One 2015;10(10):e0139923.

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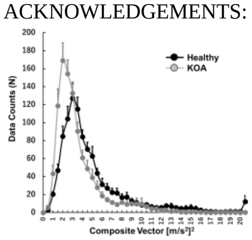

Figure 1. Counts of composite vector values are represented as the distribution of histograms from sampled acceleration data during gait in both healthy and KOA subjects. Mean and standard deviation values were shown. There is a significantly difference between Healthy and KOA distributions (ANOVA, $p<0.05$).

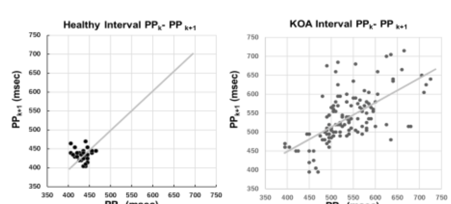

Figure 2. The variations of heel contact interval times between KOA patients and healthy subjects were compared from the Poincare plot. The gray line of this graph means both the values of PP_k and $PPk{+}1$ are equal data in this case. In other word, the peak interval data which plotted on near the gray line may have a high regularity.

Subjects	Age (years)	N & Sex (M:F)	Height (cm)	Mass (Kg)	BMI (kg/m²)
Healthy	63.4 ± 104	13 (5:8)	160.7 ± 9.9	65.1 ± 9.8	25.3 ± 4.7
Knee OA[a]	66.7 ± 8.8	20 (5:15)	157.5 ± 10.2	68.2 ± 15.7	27.3 ± 5.1

Table 1. a: Including Left and Right Knee OA patients. Mean ± standard deviation (SD) of each indicator is shown. OA: Osteoarthritis, KOA: Osteoarthritis of the knee, N: number of total subjects in each group. M: number of males, F: number of females, BMI: body mass index.