Back Muscle Fatigue during Walking in Elderly Patients with Spinal Deformity
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INTRODUCTION
Aging postural change has been generally considered an increase in thoracic kyphosis and a decrease in lumbar lordosis, which results in an anteriorization of centroidal line and an increase in anterior inclination of the body. Back muscle impairment as well as the deformity of vertebra and disc involves in the aging postural change. If an anteriorization of centroidal line occurs, back muscles might be always contracted to maintain balance during standing and walking, and patients present with pain, dullness, and feeling of fatigue in their back. Back muscle fatigue is denoted by the loss of the component of high frequency wave in electromyogram (EMG). To date, the relevance among back muscle fatigue, QOL and spinal curvature has not been well investigated.

MATERIALS AND METHODS
Nine spinal deformity patients over 50 years who have back or low back symptoms in walking were evaluated (male: 2, female: 7, mean age: 61 years). The causative diseases of spinal deformity were 7 osteoporosis and 2 spondylosis.

1. EMG of back muscle
Four wireless electrodes were attached on the back at 3cm laterally from T12 and L3 spinous process in both sides. Back muscle action potentials were recorded for 2 minutes in flat walking without aid using WEB-7000° (NIHON KOHDEN). (Fig. 1)

Fig. 1 (a) WEB-7000°, telemetry multichannel surface electromyography system is shown. (b) Four wireless electrodes are attached on the back. (c) The signal repeater is carried on the waist of the subject with belt.

Median frequency (MF) was obtained from fast Fourier transformation (FFT) analysis on the 10 seconds waveform in the initial and last period during 2 minutes walking using an analysis software QP-700H (NIHON KOHDEN). To detect the loss of high frequency wave component, the MF change was calculated as follow:

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MF \text{ change} = \frac{(MF \text{ in last 10 sec} - MF \text{ in initial 10 sec}) \times 100}{MF \text{ in initial 10 sec}}
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Lower MF change indicates higher back muscle fatigue.

2. Evaluation of Low Back Pain
Roland-Morris disability Questionnaire (RDQ) was employed to evaluate QOL of the patients. Two questions as shown below about low back pain in walking were applied to group whether the patients had gait disturbance or not.

3. I walk more slowly than usual because of my back.
17. I only walk short distances because of my back.

3. Spinal curvature and mobility
Thoracic kyphosis angle (TKA), lumbar kyphosis angle (LKA) and spinal inclination (INC) were measured using SpinalMouse® (idag AG) (Fig. 2) in neutral standing position.

Fig. 2 SpinalMouse® is a computer-assisted noninvasive device to measure spinal curvature. The spinal curvature was measured by sliding the device along the spinous processes from C7 to S3.

RESULTS
EMG discharge pattern
Periodic discharge pattern synchronized with gait cycle was observed in 2 cases. (Fig. 3 (a)) Lumbar lordosis of both cases was preserved. (LKA: -21°~ -22°) The remaining 7 patients had decreased lumbar lordosis (LKA: 19°~30°) and presented persistent discharge pattern. (Fig. 3 (b))

RDQ and MF change
There was no correlation between total RDQ scores and MF change. Grouping by RDQ concerning on walking, five patients had gait disturbances (disturbed gait group) and 4 patients had no gait disturbance (normal gait group). In comparison between two groups, median score of MF change at L3 electrodes in the disturbed gait group was much lower than the normal gait group.

Spinal curvature and MF change
Neither TKA nor LKA had correlation with MF change. The spinal inclination (INC) showed a negative correlation with MF change at T12 electrodes.

DISCUSSION
Periodic discharge pattern is generally observed in healthy subjects without low back pain. When the patients with the decreased lumbar lordosis walked, back muscle was continuously stretched and forced to be contracted. In the present study, the patients who presented the gait disturbance by RDQ showed the significantly lower MF change at L3. It indicated that the back muscle fatigue increased low back pain and impaired walking. The kyphosis of the thoracic and lumbar spine did not affect the MF changes, but the anterior inclination correlated with the reduction of MF change. The anterior inclination of the body induced the anteriorization of centroidal line and the continuous back muscle contraction leading to the muscle fatigue and the pain at the low back.

CONCLUSION
In the patients with the decreased lumbar lordosis, back muscles were continuously contracted during walking. The patients with the anterior inclination of the body showed the significant back muscle fatigue and gait disturbance.