Involvement of the Back Muscle in Gait Disturbance of Elderly Patients with Sagittal Spinal Deformity

INTRODUCTION
Lumbar degenerative kyphosis (LDK) is one of the disorders which induces chronic low back pain and gait disturbance in elderly patients in oriental countries. We postulated the gait disturbance of LDK patients would be caused not only by the deformities of the vertebral bodies and intervertebral discs but also by the back muscle impairment. The aim of this study was to reveal the involvement of the back muscle in the gait disturbance of elderly patients with sagittal spinal deformity.

MATERIALS AND METHODS
Thirty patients over 50 years who had back symptoms during walking were evaluated (male: 3, female: 27, mean age: 70 years). The causative diseases of the spinal deformity were 17 osteoporosis and 13 spondylolisthesis. Lumbar canal stenosis and osteoporotic vertebral fracture nonunion were excluded.

1. Spinal curvature and mobility
Lumbar kyphosis angle (LKA) and spinal inclination (INC) were measured using SpinalMouse® (Idiag, Volkerswill, Switzerland) in neutral standing position. INC was defined as the angle between the vertical line and the line connecting C7 to S3.

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

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 QP700H® (NIHON KOHDEN, Tokyo, Japan). To detect the loss of high frequency wave component, the MF change was calculated as follow and the mean values of both sides at each level were used for analysis

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

3. Evaluation of gait disturbance due to low back pain
According to 2 questions selected from Roland-Morris disability Questionnaire (RDQ) as shown below concerning walking, patients were divided into the disturbed gait group and the normal gait group.

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

4. Fat infiltration of the back muscle
Axial images of back muscle at T12 and L3, which consists of multifidus, longissimus and iliocostalis muscles, were acquired by computed tomography (CT). Region of interest (ROI) was outlined using Image®. Fat occupied ratio (fat/ROI ×100 (%)), which indicated fat degeneration of back muscle, was calculated. The mean values of both sides at each level were used for analysis.

RESULTS
Spinal curvature
There was a positive correlation between LKA and INC (r = 0.67, p < 0.0001).

EMG discharge patterns and spinal curvature
Periodic discharge pattern (P) synchronized with gait cycle was observed in 4 cases (Fig. 3 (a)). The remaining 26 cases presented with continuous discharge pattern (C) (Fig. 3 (b)). LKA and INC in the continuous discharge pattern group were significantly larger than those in the periodic discharge pattern group (Fig 4).

Back muscle fatigue and spinal curvature
INC had negative correlation with MF change. (Fig. 5)

Gait disturbance and back muscle fatigues
Grouping by RDQ concerning on walking, 24 patients had gait disturbances (disturbed gait group: D) and 5 patients had no gait disturbance (normal gait group: N). MF change in the disturbed gait group was significantly lower than the normal gait group.

Fat infiltration of the back muscle
The mean values of fat occupied ratio at T12 and L3 were 27.4% and 30.3%, respectively. Fat occupied ratio at T12 showed negative correlation with MF change at T12 (r = -0.41, p < 0.05). Fat occupied ratio at T12 in the continuous pattern group was significantly larger than that in the periodic pattern group (p < 0.05).

DISCUSSION
Back muscle of the patients with decreased lumbar lordosis and increased anterior trunk inclination was continuously contracted during walking. This phenomenon would be caused by extending their trunk to maintain the balance in the patients with sagittal imbalance. Continuous muscle contraction leads to back muscle fatigue and fat degeneration of back muscle. Thus insufficient back muscle could deteriorate the sagittal imbalance.

SIGNIFICANCE
Back muscle of the patients with severe sagittal imbalance was more fatigable during walking. This fatigability induced severe gait disturbance.