Existence or Nonexistence of Causable Injury Risk Possibility at Neck Joint by using Autonomous Braking (AB) in Subsequent Frontal-Head Collision at Stationary State following AB Application

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I. INTRODUCTION

The autonomous braking (AB) system has recently been implemented as an aid to avoid collision and studies have been conducted to determine its effect on collision avoidance [1-2]. However, little information is available regarding the possibility of a causable injury risk being posed by the use of AB when a subsequent frontal-head collision at a stationary state has occurred following AB application [2]. The primary aim of this study, therefore, is to identify the existence or non-existence of a causable injury risk possibility at the neck joint posed by the use of AB in subsequent frontal-head collision at a stationary state following AB application.

II. METHODS

Subjects

Thirteen healthy adult males were selected to participate in low-speed, front-head sled tests. These 13 males had no musculoskeletal or nervous system disorder, could move their cervical spine and lumbar spine freely and had no history of whiplash injury (average age, 25.6 ± 4.2 years; average height, 173 ± 2.6 cm; average weight, 70.5 ± 3.9 kg). The study was approved by Sejong University Institutional Review Board (IRB: SJU-2015-003).

Frontal-head Collision Test Platform (Sled Test Platform)

The frontal-head collision test platform was designed with a brake force control and frontal-head impact components and was validated by comparing it with an acceleration pulse pattern (longitudinal wave pattern) shown in frontal-head (Fig. 1) [3]. A mountain bicycle (MTB) oil hydraulic brake equipment (BR-M675, Japan) was mounted to serve as the brake force control component in the test platform.

Analysis of Human Responses

A subsequent frontal-head collision at a stationary state following AB application was replicated and the human responses (neck joint angle, angular velocity, muscle activation) at the neck joint were measured (Fig. 1). A frontal-head collision at a stationary state without AB application was used as a control group, in order to identify differences in the human responses due to AB application in the subsequent frontal-head collision. The participants were then instructed to sit in the car seat in a similar posture to their real sitting postures for driving, with relaxed neck and arm muscles. Neck joint angle and angular velocity were measured using a three-dimensional motion capture system with eight infrared cameras (T-10s, Vicon Motion Systems Ltd., UK; sampling rate: 200 Hz) for both frontal-head collision tests. Muscle activations were measured by a wireless surface electromyogram (EMG; Tringo Wireless EMG System, Delsys, USA; sampling rate, 2,000 Hz) attached to the sternocleidomastoid, splenius capitis and trapezius muscles. A paired students' t-test was used to identify the difference between the human responses analysed from the two frontal-head collision tests.

III. INITIAL FINDINGS

Maximum flexion angle at the neck joint in the subsequent frontal-head collision at stationary state following AB application was not significantly altered ($p>0.05$) compared to that without AB application. It was, however, occurred at a slower rate when compared to that without AB application ($p<0.05$). Unlike maximum flexion angle, maximum extension angle in the subsequent frontal-head collision at stationary state following AB application was significantly reduced ($p<0.05$) and did not appear slowly ($p>0.05$) when compared to that without AB

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application. Angular velocities were not significantly different between the two frontal-head collisions ($p>0.05$). Muscle activation patterns for the sternocleidomastoid, splenius capitis and trapezius muscles were not significantly different between the two frontal-head collisions ($p>0.05$).

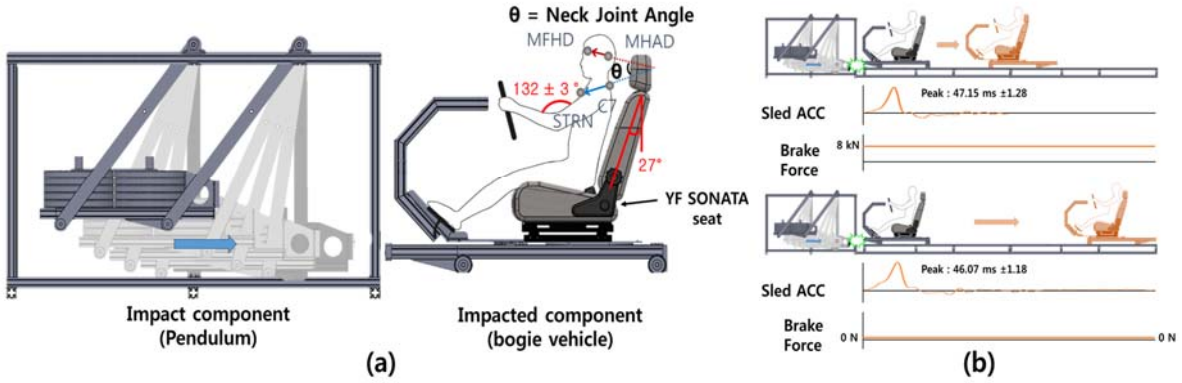

Fig. 1. (a) Frontal-head collision test platform and neck joint angle definition; (b) conditions for the subsequent frontal-head collision at stationary state following AB application (*Upper*) and without AB application (*Lower*).

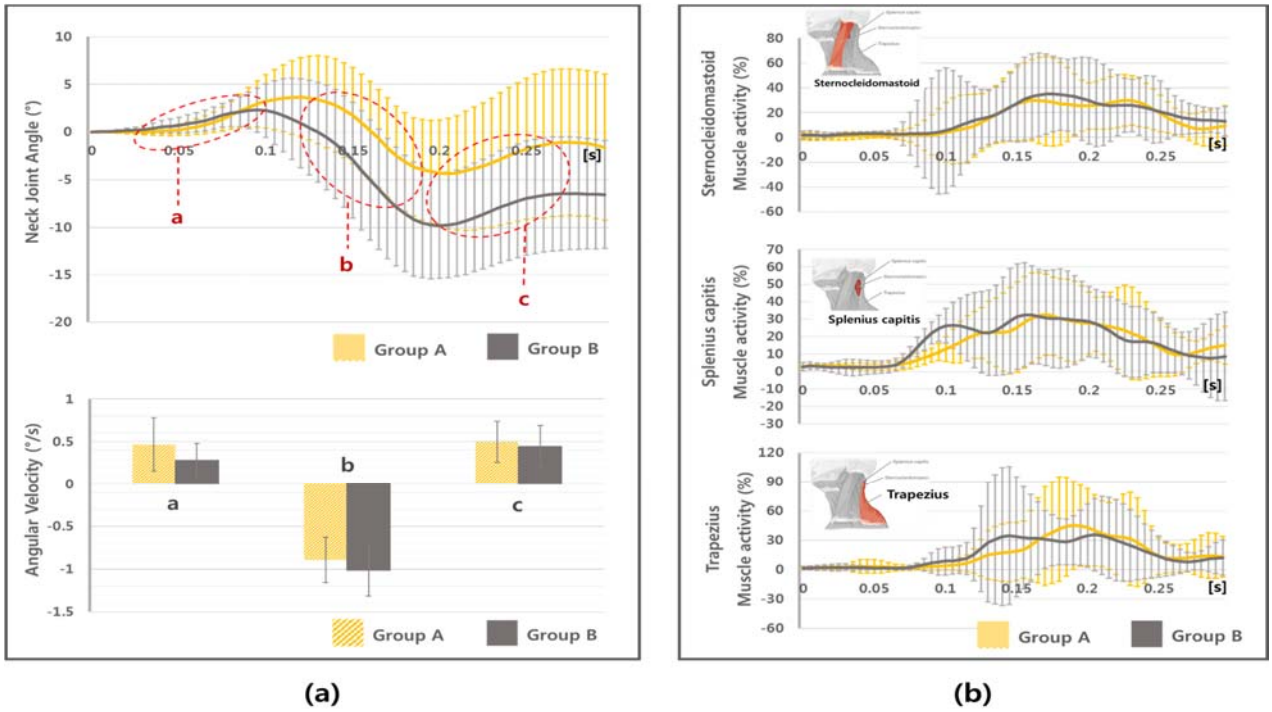

Fig. 2. (a) Neck joint angle and angular velocity; (b) muscle activation patterns for sternocleidomastoid, splenius capitis and trapezius muscles. Group A is the test group for a subsequent frontal-head collision at stationary state following AB application, and Group B is the control group for a frontal-head collision at a stationary state without AB application.

IV. DISCUSSION

The results may show that no causable injury risk possibility exists at neck joint as a result of the use of an AB system when a subsequent frontal-head collision at a stationary state has occurred following AB application. That is, the AB system in preventing collisions may have no effect on injury risk by the AB application.

V. REFERENCES

[1] Östh, J. *et al.*, *Stapp Car Crash J*, 2013.
[2] Strandorth, J., *IRCOBI*, 2012.
[3] Ito, D. *et al.*, *ESV*, 2012.