Transition of iEMG for During Straight-line Driving with One-handed Handrim Operation

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Research and development of assistive technology (AT) is becoming increasingly active in welfare and rehabilitation engineering [1–2]. Also, AT is being used to support para-sports competitors [3–4]. This study was conducted to support the athletic activities of para-athletes by developing competition wheelchairs with a mechanism that allows one-handed straight-ahead motion [5]. This wheelchair can be run straight ahead with one hand, even by people with a disability such as hemiplegia, leaving the use of only one hand. However, because the wheelchair has a special double-ring drive mechanism, the muscular load on the passenger during handrim operation has not been clarified. This report describes the muscle activity of passengers who performed a straight-line test run using a wheelchair that can run straight ahead with one hand. Preliminary test results confirmed that the passenger posture during straight-line driving with one-handed handrim operation differs greatly from that of two-handed driving and confirmed that torso rotation movement strongly influences posture. Therefore, along with the triceps brachii, which is responsible for maintaining the force to the handrim during driving, movements of three other muscles expected to affect the operating posture were measured: the latissimus, which pushes the shoulder blades down; the erector spinae, which adjusts the operating posture balance; and the oblique abdominis, which provides upper limb rotational movement. The evaluation of muscle activity is done using integrated EMG (iEMG), which can be calculated from measured surface EMG data. The sampling frequency was 1 kHz. The research participants were five healthy adult men who had experienced adequate training in wheelchair manipulation for whom the right hand was dominant. Note the use of able-bodied athletes as a limitation of the study. The research participants' height and weight were 173.2 ± 4.5 cm and 63.2 ± 4.9 kg. This study has been approved by the research ethics committee of Nagaoka University of Technology. Fig. 1 (a) portrays the one-handed operating wheelchair designed for competition. Its weight is 15.3 kg, with 350 mm seat length is, 400 mm seat width, 16 degrees camber angle, 60 mm wheel position, 590 mm wheel diameter, 19 mm tube handrim diameter, 500 mm diameter of right side handrim for the left drive wheel, and 531 mm diameter of right side handrim for right drive wheel. Fig. 1 (b) shows driving force transmission axle (DFTA) and universal joint were developed to transmit driving

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force from operation of the outer handrims to the opposite drive wheel. This experiment starts from a standstill and runs as fast as possible for eight pushes. Three attempts were made using one and two hands. After each run, a rest period was provided. Fig. 1 (c), (d) shows the transition of iEMG for triceps brachii and latissimus dorsi. The error bars in the figure represent the standard error. The triceps results show that iEMG tends to decrease with each increase in the push phase for both one-handed and two-handed drives. One-handed driving increased iEMG 1.14 times over the entire push phase more than two-handed. However, the amount of activity of the triceps muscle during one-handed driving was less than expected. A t-test was used to assess differences. A significant difference was found between the one-handed drive and the two-handed drive in the triceps brachii (p<0.01, Cohen's d=1.00) and the oblique abdominals (p<0.01, Cohen's d=6.91), while no significant difference was found in the latissimus dorsi (p>0.05, Cohen's d=0.11) and the erector spinae (p>0.05, Cohen's d=0.39). Presumably, the increase occurs in the triceps muscle activity because the one-handed drive transmits the driving force from one side to the opposite wheel through the universal joint. Additionally, the muscle activity of the oblique abdominals was assumed to increase during one-handed driving because the tendency of the posture in which the upper limb tilted toward the handrim of the driving side (right side) was confirmed through the preliminary and main experiments. In conclusion, the one-handed drive was found to maintain propulsive force by changing the operating posture rather than increasing muscle activity during the push phase.

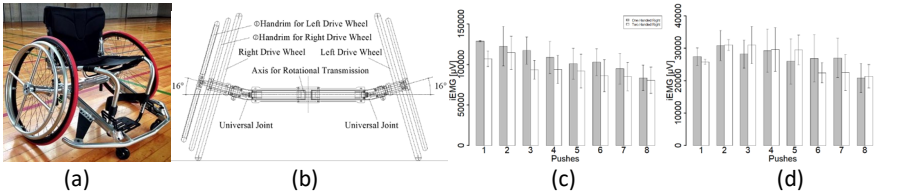

Fig. 1: One-handed wheelchair for the competition and Transition of iEMG, (a) photograph of exterior, (b) DFTA, (c) triceps brachii, (d) latissimus dorsi.

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