Estimation of car accident risk from motor function

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Abstract

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The purpose of this study is to find out the ability to driving aptitude by simple physical fitness test. Seven healthy men and four women aged 20 to 23 took the driving aptitude test and performed physical fitness test. Attention distribution test, Timing test, running vehicle test and Cognitive test. Simple physical fitness test were carried out through the driving aptitude test and chair stand test (CST) and balance test（BT）. There was a significant correlation between driving aptitude test and the CST （r=0.8 1 ,p < 0.05) . Driving aptitude test and BT were slightly correlated (r=0.261 ,p > 0.05 ） Conclusion: These results suggest that there was a relationship between chair stand test and driving aptitude test. It was also suggested that the relationship between the balance test and driving aptitude is low. It is guessed that the driving aptitude can be understood by carrying out the physical fitness test which handles the muscle used in driving.

運動機能から交通事故リスクを推定

本研究の目的は、簡易的な体力測定で運転適性を割り出すことです。方法は 20〜23 歳の健康な男性 7 人と女性 4 人が運転適性検査を行い、体力測定を実施した。運転適性検査である注意配分検査、タイミング検査、走行検査と認知反応検査を経て体力測定である chair stand test (CST)と balance test (BT)それぞれ相関係数を算出した。運転適性検査と CST は相関関係が見られたが（r=0.8 1　p < 0.05)BT との間には統計的に有意な正相関関係が見られなかった(r=0.261 p > 0.05 ）。これらの結果から、運転時に使用される筋肉を使用する chair stand test と運転適性との間には関連性があることを示唆された。また Balance test と運転適性との関連性は低いと示唆された。運転時に使用する筋肉を扱う体力テストを行うことによって運転適性が推測できるのではないか。

从运动技能推定交通事故风险

本研究的目的是简单的体力测量来判断从运动功能估计交通事故的风险，本研究的目的是通过简单的体能测量来确定驾驶能力。 七名年龄在 20 至 23 岁之间的健康男性和四名女性接受了驾驶能力测试并测量了他们的身体素质。 通过注意力分布测试、计时测试、驾驶测试和认知反应测试，这些测试是驾驶能力测试，计算了每个椅子站立测试和平衡测试的相关系数，这些测试是体能测试。驾驶能力测试与 CST 之间存在相关性（r = 0.81 ,p <0.05），但与 BT 无统计学显着正相关（r = 0.261, p> 0.05）。这些结果表明椅子站立测试，它使用驾驶时使用的肌肉和驾驶能力。 也有人建议平衡测试和驾驶能力之间的关系是低的。

Abbreviations:

CST: Chair Stand Test, BT: Balance Test.

Introduction

From 2019 to 2021, traffic fatal accidents per year from 380,000 to 330,000. Since 1949 the death toll in traffic accidents has been the smallest (ITARDA,2019). Especially, when traffic accident statistics data according to age of the National Police Agency were seen, the death toll per 100,000 population aged 20 to 24 from 2009 to 2019 was 110,600, 30 to 39 was 88961, 40 to 49 was 79,237, 50 to 59 was 51,788. And growth rate of 20 to 29 was 15%, 30 to39 was 11%, 40 to49 was 12%, 50 to 59 was 11%（E-stat,2019）. Automatic braking and automatic sensing systems have been developed, why do traffic accidents occur when car continues improve (Ministry of Land, Infrastructure, Transport and Tourism,2021). As a cause of the traffic accident, the investigation of the traffic bureau of the National Police Agency in 1993 was classified as a human factor of the traffic accident. And it is classified into the operation unsuitable, the safety confirmation, the internal unprecedented carelessness, the external precaution, and the judgment error, among them, the most common cause of traffic accident is inappropriate operation（E-stat,2019）. As a result of comparing the lowering rate of the traffic accident in 2004 to 2013, it was proven that the lowering rate of the traffic accident except for the operation suitability was 28% for lowering rate with respect to 33% for lowering rate (Ministry of Land, Infrastructure, Transport and Tourism All right reserved,2021). Therefore, it can be said that it is difficult to carry out the inappropriate operation, to prevent the accident compared with the other

traffic accident factors.

In the previous study, driver 's discomfort has gained a lot of attention, especially among interested parties (Khamis et al.2018). There are many interacting factors involving both the driver and the interior components of the car that contribute to discomfort while driving. In this study, an investigation was carried out on the contraction of the lower leg muscle among drivers when operating the accelerator pedal. The main objective of this study was to determine the pattern of muscle contraction when operating the accelerator pedal with regard to three different actions; pressing, half-pressing and releasing. Eleven participants were involved in this investigation into the muscle pattern, whereby surface electromyography (SEMG) was used to measure the activity of the lower leg muscle, known as the tibialis anterior (TA). The data collection procedure on the selected muscle was in accordance with the SEMG recommendations for the Non-Invasive Assessment of Muscles. Based on the results, the TA depicted that the highest muscle contraction occurred during the releasing action. In addition, there were significant differences between each action in the T-test analysis with $p < 0.05$. It can be concluded that the TA muscle works differently based on the car pedal actions (Khamis et al.2018).

In other previous study, the effect of stroke on the steering of the car was examined. The hand paralyzed by the result of stroke was restricted to motor function due to the grip control defect, which failed to manipulate the operation ability ($r = 0.49$, $P < 0.05$). In addition, previous studies have

shown similar results in 11 patients with motor dysfunction and 11 diabetic patients (without neuropathy) in the previous study. The influence of the driving simulator on the control of the accelerator pedal by the driving simulator is as follows. The control of the accelerator pedal of 11 healthy persons was found to be affected by the muscle function of ankle joint strength and tibialis anterior , the intrinsic receptive sense and the control of the accelerator pedal(p=0.023)（Prrazzolo et al.2020）. Two experiments(Khamis et al.2018,Prrazzolo et al. 2020).showed the relationship between driving ability and motor function.

The purpose of this study is to find out the possibility of preventing a traffic accident by measuring motor function by simple physical fitness measurement and dividing the relationship between driving ability and motor function.

As a hypothesis, I think that it is possible to have the relation between driving aptitude test and simple physical fitness test. In the chair stand test of the item of the simple physical fitness test, the muscle of the thigh is used（Khamis et al.2018,Gao Z et al.2015). The gastrocnemius and tibialis anterior muscles, which are necessary for driving, are rarely used, but it seems that the relationship can be seen by using a little with the thigh muscles. Therefore, it is thought that there is the driving suitability as the result of the simple physical fitness test is good. And, since it is simple physical fitness test, it can be easily measured without using an instrument or time. In order to measure the strength of the lower body of the elderly and the stroke patient, the simple measurement can be

measured regardless of age (Johansen KL et al.2016, Jones CJ et al.1999). When CST and the four items of driving aptitude test are separated one by one, the accelerator pedal and brake pedal are used for CST and driving test. There is a relationship between the two because the thigh muscles used in CST and a few gastrocnemius and tibialis anterior muscles are used（Khamis et al.2018,Gao Z et al.2015). Since the timing inspection uses only the button for the investigation, the relationship between the two is low. Since the attention distribution test is mainly a handle investigation, it has a low relationship with CST, which is related to the muscles of the foot. The cognitive reaction test mainly investigates the steering wheel, but since it uses the brake pedal and the accelerator pedal, a relationship can be seen. Comprehensively, if the results of the same physical fitness test are high for some of the muscles used, the result of the driving aptitude test will be better, so a relationship can be seen. The relationship between BT and the running test is low because the muscles used in the balance test and the gastrocnemius and tibialis anterior muscles used in the running test are different. The relationship between BT and timing inspection is low because only buttons are used for timing inspection. Similarly, the gastrocnemius and tibialis anterior muscles are not used in the BT, attention distribution test, and cognitive response test, so the relationship is low. Since the relationship between the three items is low overall, the relationship between BT and the driving aptitude test is considered to be low.

Materials and Methods

Participants

The experiment participated in an experiment for 11 healthy student of 20-23 years old. All participants were instructed to stop the act of feeling intense exercise, drinking alcohol and fatigue 24 hours before the experiment. The chair stand test and the balance test were carried out as a simple physical fitness test. After that, participants took a driving aptitude test.

Experimental design

Driving aptitude test is consist of attention distribution, timing test, running vehicle test and cognitive reaction test. Attention was made in a quiet room for prevention of distraction.

The participants conducted a test using Simple Driving Simulator S (SiDS,TAKEI Equipment Industry Co) to test their driving aptitude. The trial time is 10 minutes for attention distribution test, 5 minutes for timing test, 8 minutes for running vehicle test, and 8 minutes for cognitive reaction test. In this test, handle and foot pedal which are used in car simulation games were used (logicool g steering controller lprc-15000d,logicool). After the completion of each inspection, the standard area, the obstacle area, the boundary area and the numerical value representing the degree of accuracy are determined following the previous study. Attention distribution test in order to examine the attentional distribution, the operator checks the pedal according to the color of the signal while

focusing on the handle. When the instruction of red comes out, the foot is pulled from the accelerator and the brake is stepped. When yellow instruction comes out, the foot is taken from the accelerator and waits. When there is a blue display, keep pressing the accelerator pedal. Timing inspection is only the button of the handle is used to inspect the running time of the car. It is estimated by the button length pushing that the car moving from left to right comes to the building. Running vehicle test is keep a safe inter vehicle distance and follow the blue car. When the color of the signal changes, it must stop in accordance with the rule. Cognitive response test in the case of red in the inspection to operate the pedal according to the signal, the foot is applied to the brake pedal from the accelerator. If it is yellow, take foot off the accelerator and wait. In the case of blue, the accelerator continues to tread. Driving aptitude test is Instruct to avoid intense exercise before the exam. Attention was made in a quiet room for prevention of distraction. For the simple fitness test, participants did chair stand test and balance test. Chair stand test records the number of times participants can stand up from chair in 30 seconds. Balance test that measures how many seconds can stand on one leg. Each test rating is not marked. In this experiment, participants were able to stand up for 30 seconds and observe the number of records that can be kept for many seconds. This test uses the thigh muscle. tibialis anterior muscle and gastrocnemius muscle are example of muscles used during driving. (Khamis NK, Deros BM & Nuawi MZ.2018) (Gao Z, Li C, Hu H, Chen C & Yu H.2015) These tests do not use exercise equipment and simple rules so it is not only by young people to old people.

The Shapiro- Wilk test of SPSS was performed to determine the normality of Date distribution. And, the chair stand test of the physical fitness measurement and balance test were individually carried out on the Shapiro Wilk test of SPSS, and it was judged that the chair stand test had the normality, and the Spearman correlation coefficient was carried out. It was not possible to judge that there was normality in the balance test, and the correlation of the non parametric test was made. Degrees of correlation was judged as shown below; r＝1.0~0.7: Fairly correlated, r＝0.7~0.4, fairly correlated; r＝0.4~0.2, with a fairly strong correlation; r＝≦0.2, almost without correlation. (Mitchell H.2006)

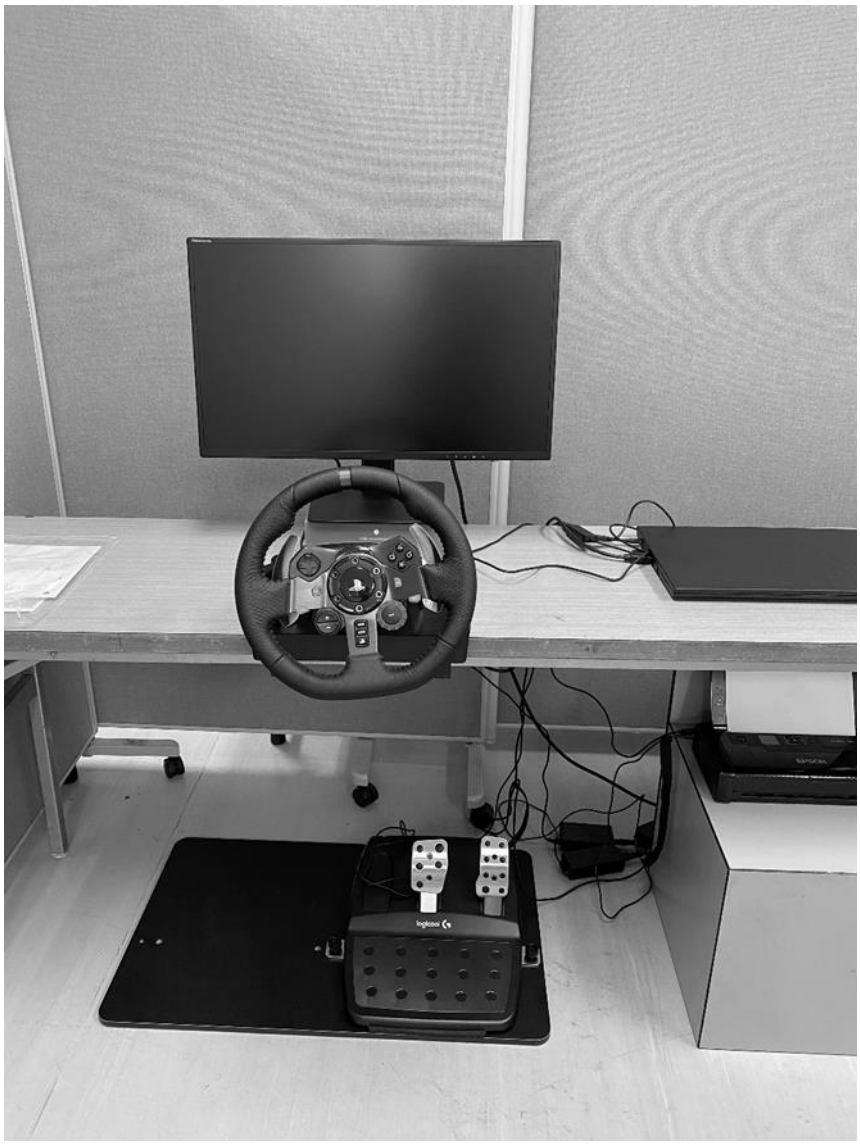

Fig. 1 Experimental set up for driving aptitude test

Fig. 2 Experimental set up for chair stand test

Fig3 Experimental set up for balance test

Results

Correlation analysis, driving aptitude test(r＝0.515 , P＞0.05） ,Chair stand test(r＝0.735, P＞0.05） ,balance test （r＝0.000 , P＜0.05） As a result of Spearman's correlation coefficient, the hypotheses of CST and driving inspection (r＝0.509, p<0.5)(Fig.4), and CST and driving aptitude test (r＝0.506, p<0.5） (Fig.8)were supported. The reason is that the gastrocnemius and tibialis anterior muscles used in CST are the same muscles used when using the accelerator pedal and brake pedal in the running test. CST and timing test (r = 0.237, p > 0.5)(Fig.5), CST and attention distribution (r = 0.321, p > 0.5)(Fig.6), CST and cognitive response test (r = 0.227, p >0.5)(Fig.7), BT and running test (r = 0.259, p > 0.5)(Fig.9), BT and timing test (r = 0.09, p > 0.5)(Fig.10), BT and attention distribution test (r = 0.107, p >0.5)(Fig.11), BT and cognitive response test (r = 0.166, p > 0.5)(Fig.12), BT and synthesis (r = 0.225, p> 0.5)(Fig.13) did not support the hypothesis. As mentioned in the hypothesis, the reason is that CST and timing test, and BT and timing test use only buttons, so the relationship is low. Since CST and attention distribution inspection are mainly for steering wheel investigation, they are different from the muscles used in CST, so there was no relationship. Although the CST and the cognitive response test are centered on the steering wheel investigation, it was hypothesized that there is a relationship because the brake pedal and the accelerator pedal are used, but the relationship was low because the steering wheel investigation was the main focus. As hypothesized, the relationship

between BT and the attention distribution test and cognitive response test was low because the relationship between BT and the muscles used in each test was low.

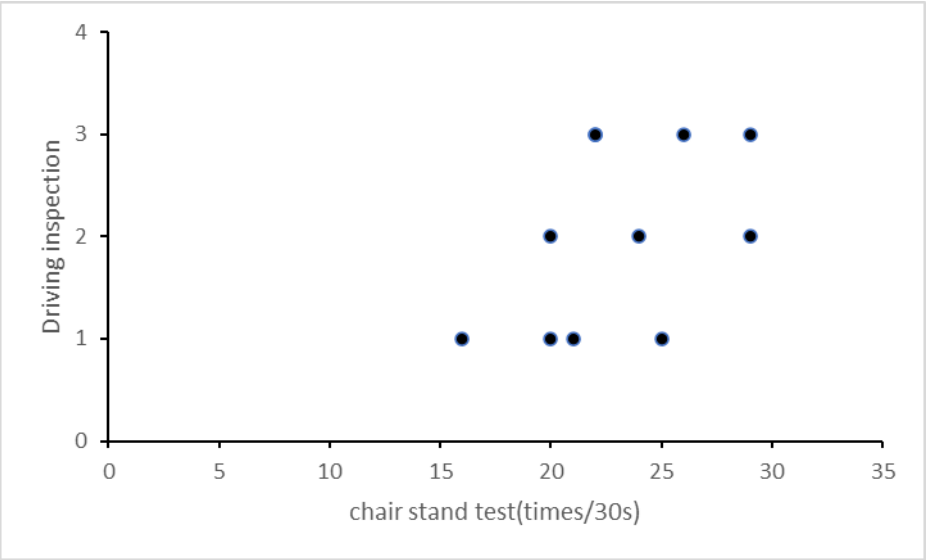

Fig.4 correlation between Driving inspection and chair stand test ($r=0.509$, $p<0.05$).

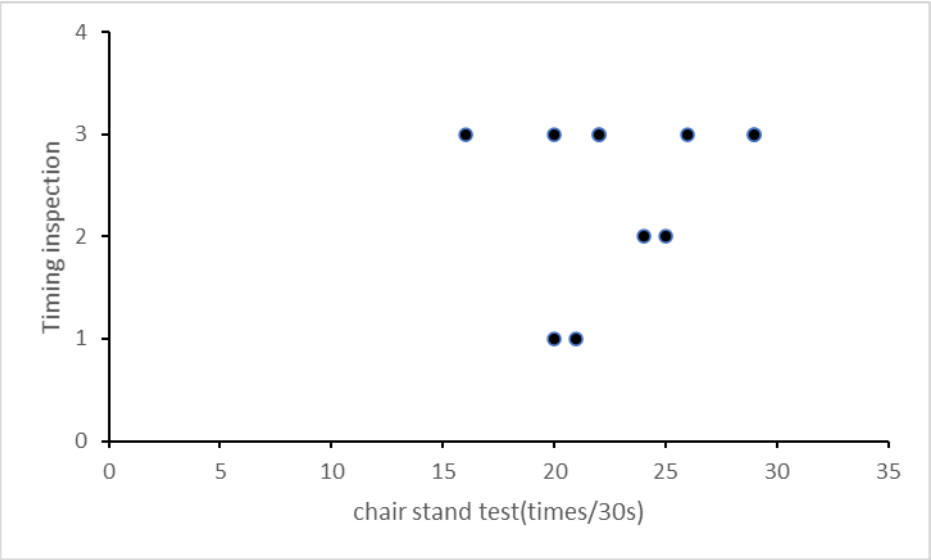

Fig.5 correlation between Timing inspection and chair stand test($r=0.237$, $p>0.05$).

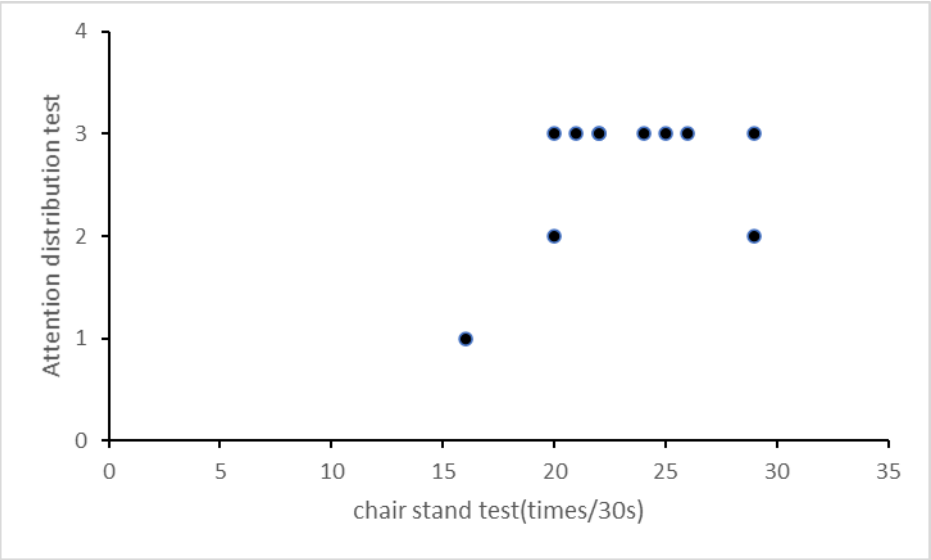

Fig.6 correlation between Attention distribution test and chair stand test ($r=0.321$, $p>0.05$).

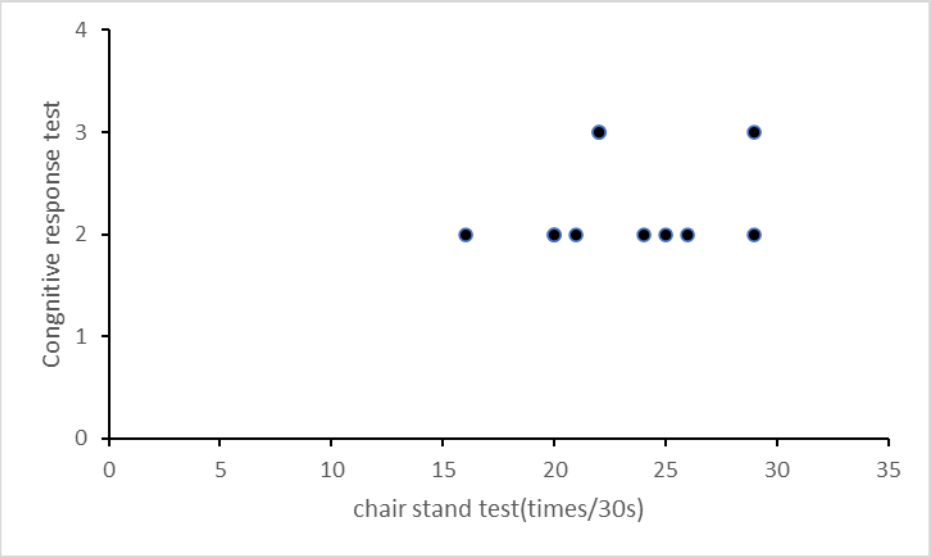

Fig.7 correlation between Cognitive response test and chair stand test($r=0.227$, $p>0.05$).

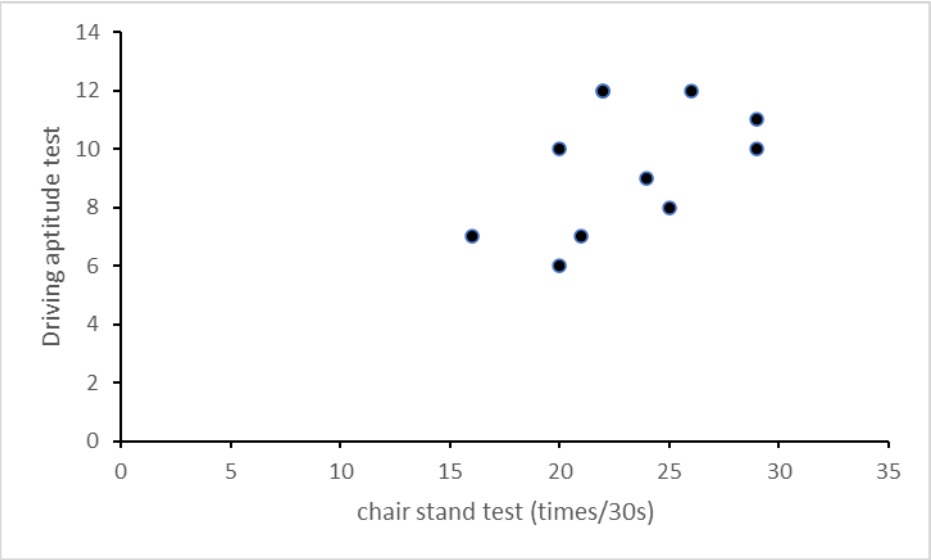

Fig.8 correlation between Driving aptitude test and chair stand test ($r=0.506$, $p<0.05$).

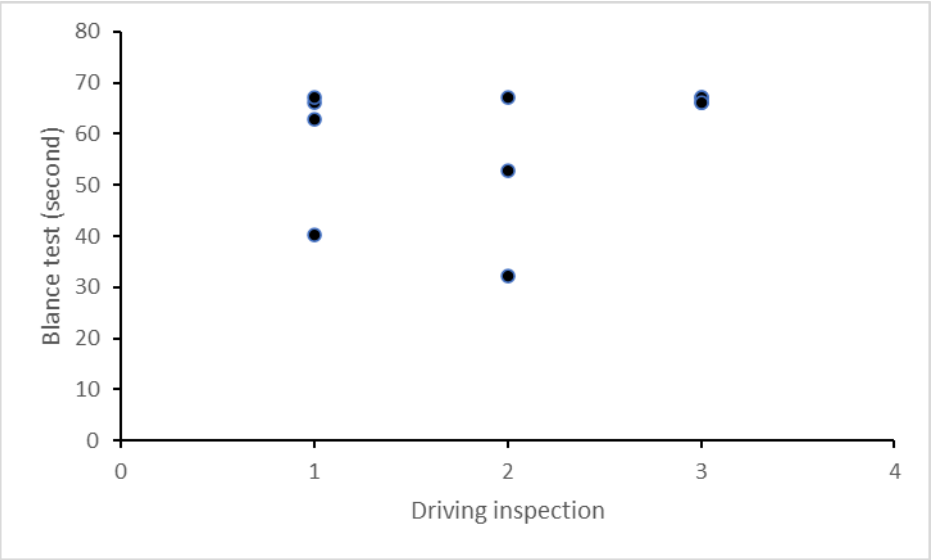

Fig.9 correlation between Driving inspection and Balance test ($r=0.259$, $p>0.05$).

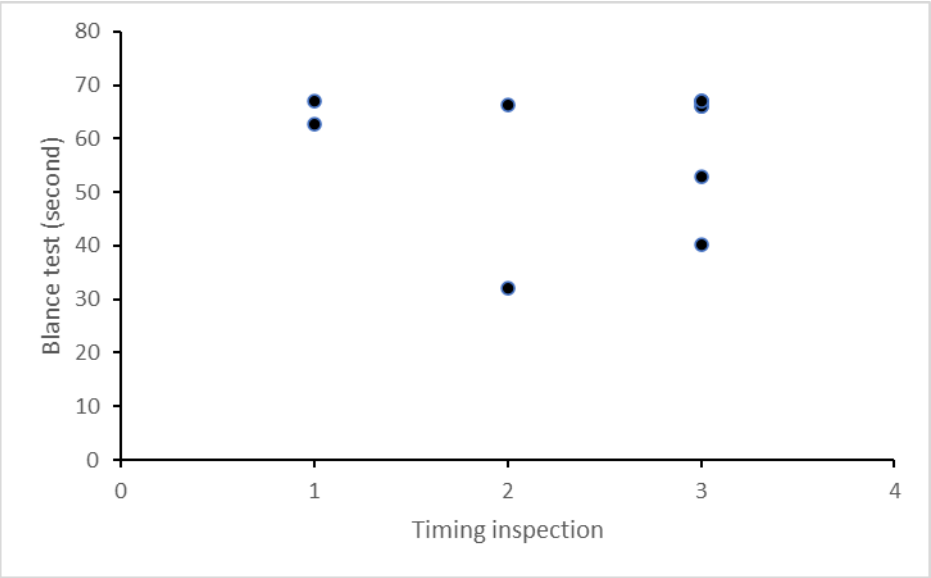

Fig.10 correlation between Timing inspection and Balance test($r=0.090$, $p>0.05$).

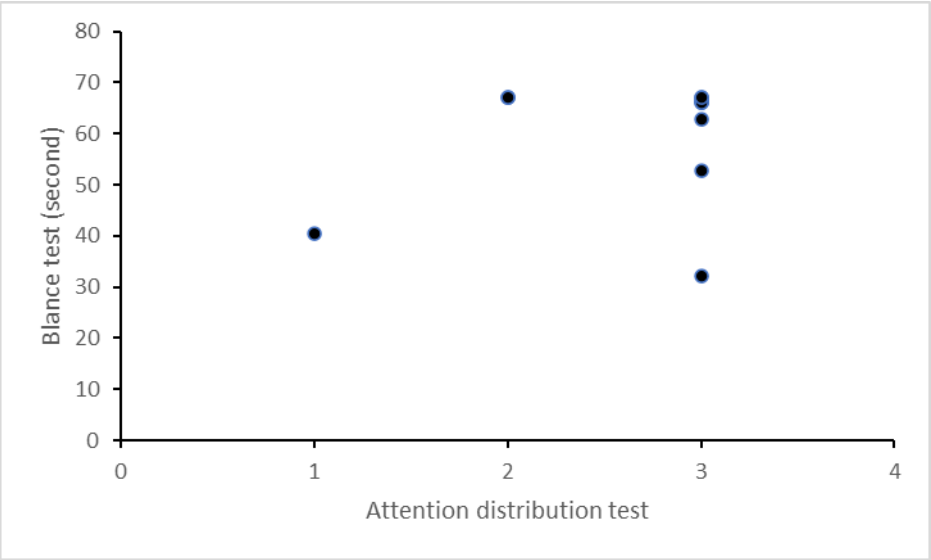

Fig.11 correlation between Attention distribution test and Balance test($r=0.107$, $p>0.05$).

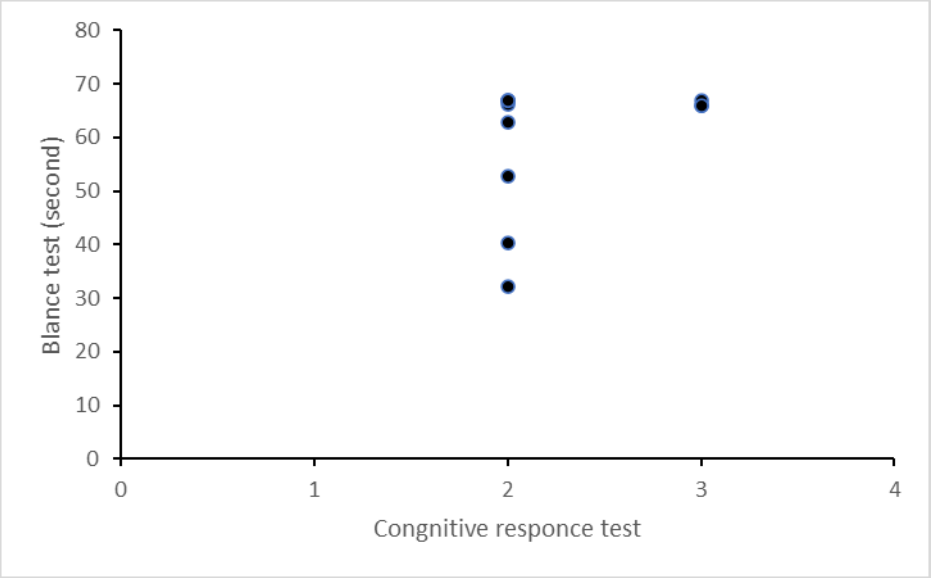

Fig.12 correlation between Cognitive response test and Balance test($r=0.166$, $p>0.05$).

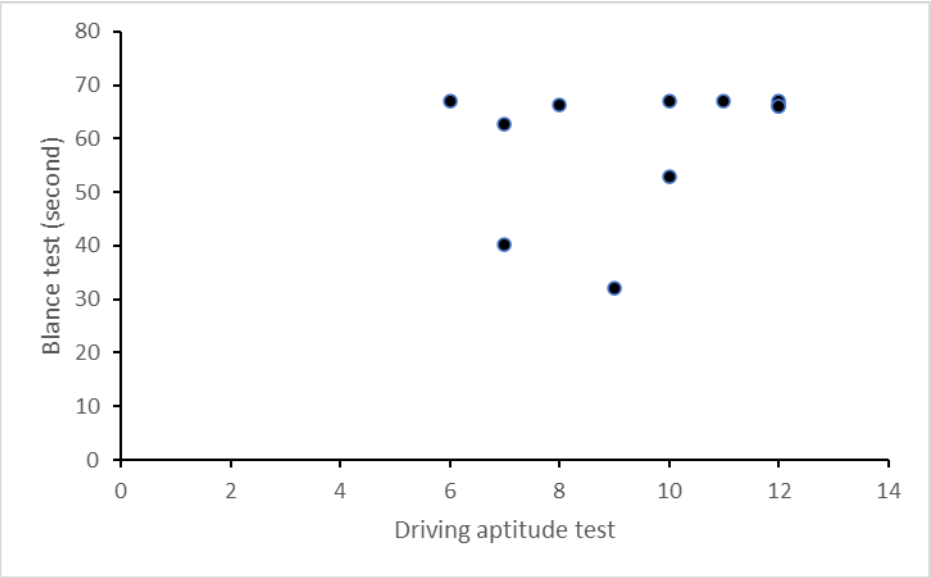

Fig.13 correlation between Driving aptitude test and Balance test($r=0.225$, $p<0.05$).

Discussion

In this study, the purpose of this study was to understand the usefulness of the measurement by simple physical fitness as a hypothesis, the muscles of thigh used for the chair stand test and the balance test for simple physical fitness test. As a result of Spearman's correlation coefficient, the hypotheses of CST and driving test(r＝0.509, p<0.5), and CST and driving aptitude test (r＝0.506, p<0.5） were supported. It seems that the thigh muscles used in CST are used in driving tests as the reason why the hypothesis was supported. So far, we have focused on the tibialis anterior muscle and the gastrocnemius muscle, but from the results of CST and running tests, it seems that the thigh muscle is also involved when using the accelerator pedal and brake pedal. CST and timing test (r = 0.237, p >0.5), CST and attention distribution (r = 0.321, p> 0.5), CST and cognitive response test (r = 0.227, p >0.5), BT and running test (r) = 0.259, p >0.5), BT and timing test (r = 0.09, p >0.5), BT and attention distribution test (r = 0.107, p >0.5), BT and cognitive response test (r = 0.166, p> 0.5), BT and synthesis (r = 0.225, p >0.5) did not support the hypothesis. As mentioned in the hypothesis, the reason is that CST and timing test, and BT and timing test use only buttons, so the relationship is low. Since CST and attention distribution inspection are mainly for steering wheel investigation, they are different from the muscles used in CST, so there was no relationship. Although the CST and the cognitive response test are centered on the steering wheel investigation, it was hypothesized that there is a

relationship because the brake pedal and the accelerator pedal are used, but the relationship was low because the steering wheel investigation was the main focus. As hypothesized, the relationship between BT and the attention distribution test and cognitive response test was low because the relationship between BT and the muscles used in each test was low. It is considered that this has a low relationship between the gastrocnemius muscle and the tibialis anterior muscle used during the BT and driving (Khamis NK et al.2018,Gao Z et al.2015).

This time, we conducted an experiment under the name of simple physical fitness measurement, but it seems that a more accurate relationship can be found when the measurement is performed focusing on the muscles used when operating the pedal and operating the steering wheel （Patel P et al.2019）.The reason for using the balance test, which is considered to be low correlation, is that it is easy to measure the simple physical fitness test of any place without using an instrument. The reason why the femur muscle will contribute strongly is because it is also simple physical fitness test. From this point of view, it was necessary to measure mainly the gastrocnemius and anterior tibialis muscle from the chair stand test using the thigh. In this study, it was clear that simple fitness test couldnot make clear operation suitability. This research was targeted young people, but as an experiment content, it can be practiced by people of all ages, and if it is possible to determine motor function anywhere, it is possible to take early measures to prevent the traffic accident that is occurring now. This time, we focused on motor function, but by clarifying the close relationship between

cognitive function and driving aptitude and conducting experiments, we may be able to find the possibility of reducing traffic accidents to zero. In conclusion, it can not say that even a simple physical fitness test has a relationship with driving aptitude, but there is room for improvement.

Reference

Baewert A, Gombas W , Schindler S ,Peternell-Moelzer D , Eder H ,Jagsch R, Fischer G.(2017).Influence of Peak and Trough Levels of Opioid Maintenance Therapy on Driving Aptitude . Eur Addict Res 13:127–135

Case HW, Hulbert S, Beers J. Driving ability as affected by age. Final report (No 70-17). Los Angeles: Institute of Transportation and Traffic Engineering, 1970.

e-stat (2019) Road traffic accident statistics

Fujita K, Kobayashi Y, Sato M, Hori H, sakaki R, Ogawa T.(2021). Characteristics of Pedal Operation by Elderly Drivers during Emergency Braking.Healthcare9(7),852,2021

Gao Z, Li C, Hu H, Zhao H, Chaen C, Yu H. Simulator study of young driver's instinctive response of lower extremity to a collision. Traffic Injury Prevention, 16 Sep 2015, 17(4):423-429

Gao Z, Li C, Hu H, Zhao H, Chaen C, Yu H. (2016). Muscle activity and co-contraction of musculoskeletal model during steering maneuver. Bio-medical materials and engineering 24(6), 2697-

Jammes Y, Behr Y, Weber JP & Berdah S. Consequences of simulated car driving at constant high speed on the sensorimotor of leg muscle and the breaking response. Clin Physiol Funct Imaging. 2017 Nov.

Joxsson S, Jonsson B .(1975). Function of the muscle of the upper limb in car driving IV: the pectoralis major. serratus anterior and latissimus dorsi muscle1.Ergonomics.18,643-649

Khamis NK, Deros BM,&Nuwai MZ.(2018). Pattern of Muscle Contraction in Car Pedal Control. Jurnal Kejuruteraan 30(1),23-29 2018

Kornatz KW Christou EA Enoka RM . Practice reduces motor unit discharge variability in a hand muscle and improves manual dexterity in old adults. J Appl Physiol (1985). 98:2072–2080

Lodha N, Moon H, Kim C, Onushko T, Chirstou EA. (2016). Motor output variability impairs driving ability in older adult . Journals of Gerontology series A (12) ,1676-1681 (2016)

Mehrabi N, Sharif M, Mcphee J.(2012) .Study of human steering tasks using a neuromuscular driver model Advanced Vehicle and Control Conference (AVEC) . Acta Psychologica 47(2),143-148

National Police Agency (2020) About the occurrence situation of traffic accidents in the second year of Reiwa. 18Feb

Patel P, Alam T, Tracy BL & Lodha N .(2019). Impaired force control contributes to car steering dysfunction in chronic stroke. Published online: 06 Nov 2019 1948-1954

Perazzolo M, Reeves ND, Bowling FL, Bouiton AJM, Raffi M, Marple DE (2020) Altered accelator pedal control in a driving simulator in people with diabetic peripheral neuropathy. Diabetic medicine 37 (2), 335-342,2020

Pick AJ, Cole DJ(2008) A mathematical model of driver steering control including neuromuscular dynamics. Journal of Dynamic Systems, Measurement, and Control, 130(3), 2008.

Pick AJ, Cole DJ.(2006). Measurement of driver steering torque using electromyograpy. Jounal of Dynamic Systems, Measurement, and Control 128,960-968

Pick AJ, Cole DJ(2006) Measurement of driver steering torque using electromyography. Journal of Dynamic Systems, Measurement, and Control, 128(4), 2006.

Sugano T, Kawabata K, Hitosugi M .(2021). Kinematic and Electrophysiological Characteristics of Pedal Operation by Elderly Drivers during Emergency Braking . (2018). Healthcare 2021, 9(7), 852

Mitchell H. (2006). Study Design and Statistical Analysis. CAMBRIDGE UNIVERSITY PRESS,5.7 100-105

Vaillancourt DE Larsson L Newell KM . Effects of aging on force variability, single motor unit discharge patterns, and the structure of 10, 20, and 40 Hz EMG activity. Neurobiol Aging. 2003;24:25–35

Xu J, Ejaz N, H Benjamin, Branscheidt M, Widmer M, Faria AV, Harran MD, Cortes JC, Kim N, Celnik PO, Kitago T, Luft AR, Krakauer JW & Diedrichsen J .(2017).Separable systems recovery of

finger strength and control after stroke. Journal of Neurophysiology 118 (2), 1151-1163, 2017