ANALYZING BRAKE FORCE AMONG DIFFERENT DEMOGRAPHICS

by

Makenzie Steidl

A Signature Honors Project Presented to the

Honors College

East Carolina University

In Partial Fulfillment of the

Requirements for

Graduation with Honors

by

Makenzie Steidl

Greenville, NC

May, 2023

Approved by:

Anne Dickerson

Department of Occupational Therapy

Abstract

Driving is a very important activity that allows people to maintain their independence. The purpose of this study was to investigate brake force concerning different demographics in hopes to increase safety and confidence on the road. Data for this study was collected on one hundred thirty-two subjects by using a Brake and Time Reaction Tester. There was a significant difference found in brake force averages between biological sex. There was no significant difference found in brake force averages among different age groups nor in the number of days driven per week. This study suggests that there is variability in an individual's performance of brake force. However, when taking the averages of each individual's brake forces, most fall within a couple of standard deviations from the mean.

Introduction

Mobility and transportation are essential for people to be able to access health services, work, social activities, and more. Being able to drive allows one to have a sense of independence, control, and responsibility (Dickerson et. al., 2014). Driving as the primary mode of community mobility is an important instrumental activity of daily living (IADL) in the occupational therapy profession. A previous study indicated that older adult stroke patients' main goal in recovery was to resume driving (Dickerson et. al., 2013).

Driving is a complex task that requires people to multitask their cognitive and physical abilities. As individuals age, their ability to drive may become restricted due to various reasons. In fact, drivers who are 65 and older are at greater risk for fatal crashes due to frailty and fragility (*Older Drivers*, 2022). Older adults may face car pedal errors, visual attention deterioration, decreasing processing speed, decreasing joint flexibility and muscle mass, and difficulty with

task completion (Baldock 2004 & Bedard et. al. 2006 & Freund et. al. 2008 & Vance 2009). Being able to effectively determine who is and is not fit to drive, while focusing on functional skills rather than age, is an important goal of driving rehabilitation.

Another population who may face driving restrictions includes those recovering from lower extremity injuries or surgeries. There have been numerous accounts where patients are left recovering from an injury or surgery, without knowing when they will be able to drive again. Unfortunately, clinicians do not have a baseline to follow to advise the patient when it would be safe to drive again. As stated in a recent study article, after patients inquire about when they can drive, "…These questions typically remain unanswered as there are no standardized recommendations" (Kirschbaum et. al., 2021). There have been recent developments in driving assessments, however, there is no universal driving assessment tool, and many driving rehabilitation specialists make their own fit-to-drive tests based on evidence-based practices. Current physical assessments test motor skills by evaluating clients' range of motion and finger-grasping skills. These tests are beneficial, but do not assess the lower extremity's ability to perform an emergency brake stop (Dickerson et. al., 2014).

Brake force refers to the force applied to the brake pedal to slow down an automobile. This study uses a brake force simulator to predict one's fitness to drive while testing its reliability based on observational data collection. This study is hoping to further investigate significant differences in brake force among different demographics. By analyzing trends in brake forces, the goal is to create a better understanding and provide norms for determining when people can safely drive again after injuries. It is also a goal to measure fitness to drive within older populations.

Methods

Design

A cross-sectional design was used in this study. This observational study allowed the investigator to measure the outcome of brake forces among different demographics. In doing so, many variables were compared simultaneously.

Instrumentation

The data for this study was collected by using a Brake and Time Reaction Tester from Advanced Therapy Products, Inc. in Virginia, U.S. This simulator is a replica of an automobile accelerator and brake pedal with a red and green light box and a digital tablet. When all parts are electronically connected, the investigator can easily set up the portable test and randomly initiate the red light to illuminate during the testing trials.

Procedure

Participants were asked to adjust their chairs in front of the simulator as if they were driving a car. The light box was set up in front of them so that it was easily visible. It was suggested to have their legs at a 90-degree angle. After the operator resets the test using the digital tablet, the subject is asked to push down on the accelerator with their right foot and hold it, illuminating the green light on the light box. Once the red light randomly illuminates (based on the operator's command), the subject pushes down on the brake as hard and as fast as they can with their right foot. Each subject is allowed three practice runs if needed, and then the next five trials are recorded. The brake force is recorded in pounds and each subject's five trials are averaged.

Participants

Subjects were recruited from various locations in North Carolina at different times. The demographics of each subject are recorded at the time of the study which includes the subject's biological sex, age, race, number of days they drive per week, and their self-reported health status on a Likert scale of one to five (one meaning poor, two meaning fair, three meaning good, four meaning very good, and five meaning excellent). The total sample size for this study included 132 subjects, 51 of which were male and 81 females. The subjects were aged 18-83 years old. Figure 1 demonstrates the distribution of races in the sample population used.

Figure 1: Races of the Sample Population

Race						
	White	Black	Asian	Hispanic	Mixed	Other
Number of Participants	93	27	1	7	3	1

No subject stated that their health was "poor," and only one subject stated that their health was "fair." The rest self-reported either a "good," "very good," or "excellent," health status. For the age group comparison, ages were grouped as followed: Young Adults (18-39), Middle-Aged (40-64), and Older Adults (65 and up). Since there were only two subjects who were 65 and up, the Older Adults age group was excluded from the t-test when analyzing significant differences among age groups.

Results

Brake Forces (in pounds) were evaluated through descriptive statistics, charts, and graphs. Figure 2 displays the overall statistics of the entire sample population (see Figure 2). Figure 3 displays the proportion of different self-reported health statuses among the sample population (see Figure 3). It is shown that approximately 99% of the subjects stated that their health was either "good," "very good," or "excellent," which indicates that these results are based on a healthy population. Independent t-tests were used to determine if there was a significant difference among average brake forces between sex and age groups, using a significance level of .05 (see Figures 4 and 5). There was a significant difference between average brake forces among males and females ($t=3.65$, $p<.001$). Males had an average brake force of 79.18 pounds while females had an average brake force of 62.79 pounds. There was no significant difference between average brake forces among young and middle-aged adults ($t=-.613$, $p=.270$). A one-way ANOVA test was used to compare brake forces with the number of days driven per week (see Figure 6). It was concluded that there was not a significant difference in brake force when compared to the number of days driven ($F(2, 129)=.583$, $p=.560$).

Figure 2: Statistics of Sample Population in Years

N = 132	
Average Age	36.53
Median	36.50
Mode	18
Standard Deviation	13.23
Minimum Age	18
Maximum Age	83

Figure 3: Self-reported Health Status of the Sample Population

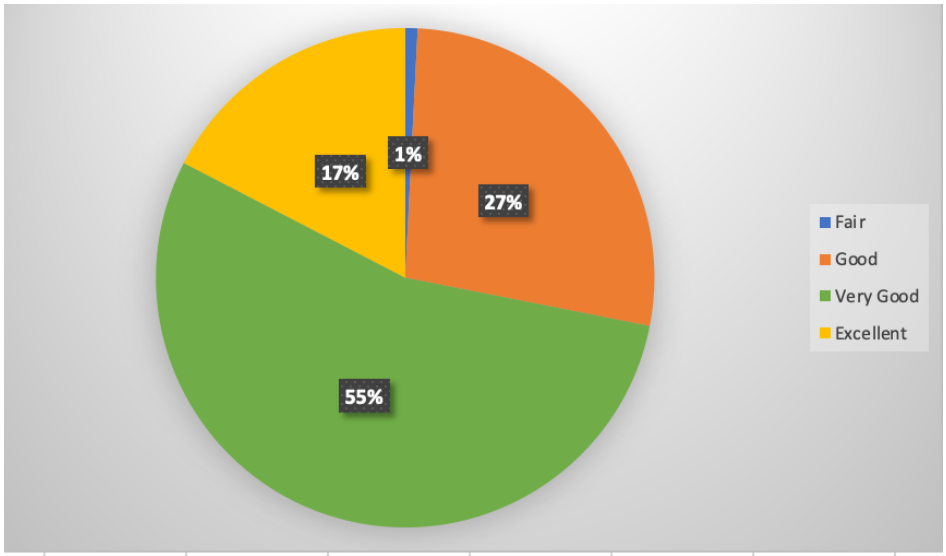

Figure 4: Significance between brake force and biological sex

	N	Mean Brake Force in lbs. (SD)	
Male	51	79.18 (29.15)	**t=3.65, p<.001**
Female	81	62.79 (16.97)	

Figure 5: Significance between brake force and age groups

	N	Mean Brake Force in lbs. (SD)	
Young Adults (18-39)	74	68.14 (24.96)	**t=-.613, p=.270**
Middle Age (40-64)	56	70.75 (22.59)	

Figure 6: Significance between brake force and days driven per week

Days driven out of the week	N	Mean Brake Force in lbs. (SD)	
1-2 Days	6	59.87 (27.06)	**F(2, 129)=.583, p=.560**
3-6 Days	34	67.93 (21.50)	
7 Days	92	70.17 (24.44)	

Discussion

The results prove that there is a significant difference in brake force between biological males and females, with males having a higher brake force. This is not surprising considering males are usually stronger in their lower extremities compared to females. Males tend to have a higher hamstring-to-quadriceps force than females (Hannah et. al., 2015). The majority of females (68%) have a brake force that ranges between 45.82 and 79.76 pounds. When applying this research to future fitness-to-drive evaluations and interventions, it is suggested that any female who can press a brake force in between this range is likely safe to drive in this aspect. About 68% of males had an average brake force ranging between 50.03 and 108.33 pounds. This range is much larger than the females but can still be used as a reference for safe driving in males. Therefore, if a male can press the brake pedal in between the range of 50.03-108.33 pounds, they are likely safe to drive in this aspect. There was no significant difference in brake force among different ages (see Figure 5). Therefore, brake force is consistent regardless of someone's age. There was no significant difference in brake force among days driven per week.

This study gives further evidence that driving restrictions should be based on individual functionality assessments rather than strictly on age or disability. The Brake and Time Tester simulator had decent reliability based on the operator's observation. It will likely be beneficial to implement this simulator in driving rehabilitation interventions. This study is a first step in developing a baseline of brake force based on demographics and norms for men and women. It would be beneficial to utilize the simulator to determine a patient's individual brake force before an operation to then use as a goal to reach after surgery. In a previous study, brake force was measured before and after operations and showed a significant reduction (Kirschbaum et. al., 2021). This same study suggests that brake force should be evaluated on an individual basis.

Being able to set baseline goals for each patient might be a beneficial way for clinicians to feel more confident to clear their patients to drive.

Limitations

There were a few statements made by subjects who felt as though the simulator felt quite different than a "normal" automobile brake pedal. It is also important to recall that some subjects may not have been taking the test as seriously as others, possibly accounting for some of the lower brake forces. There were a few situations where the operator had to remind the subjects to hit the brake pedal with their right foot instead of their left. Some subjects stated that they usually brake with their left foot when driving while only using their right to accelerate.

Conclusion

The Brake and Time Reaction Tester Simulator is an efficient way to measure lower extremity mobility and force. It is important to continue to discover potential motor assessments that evaluate people's fitness to drive. Clinicians can potentially use this simulator in the future to measure patients' brake forces before and after surgery to gain insight into when they will be able to effectively drive again. This study also created a standardized range of normal brake forces for males and females that can be referenced during fitness to drive evaluations and injury recovery. Although brake force is not the only aspect that can or should effectively determine an individual's ability to drive, it can serve as a reliable component of safe driving evaluations.

References

Baldock, M. R. J. (2004). Self-regulation of the driving behavior of older drivers. Available at http://digital.library.adelaide.edu.au/dspace/handle/2440/37930.

Bedard, M., Leonard, E., McAuliffe, J., Weaver, B., Bibbons, C., & Bubois, S., (2006). Visual attention and older drivers: The contribution of inhibition of return to safe driving. Experimental Aging Research, 32, 119-135.

Dickerson, A. E. (2013). Driving Assessment Tools Used by Driver Rehabilitation Specialists: Survey of Use and Implications for Practice. *The American Journal of Occupational Therapy, 67*(5), 564-73. https://doi.org/10.5014/ajot.2013.007823

Dickerson, A. E., Meuel, D. B., Ridenour, C. D., & Cooper, K. (2014). Assessment tools predicting fitness to drive in older adults: a systematic review. *AJOT: American Journal of Occupational Therapy*, *68*(6), 670+. https://link.gale.com/apps/doc/A392070183/HWRC?u=ncliveecu&sid=summon&xid=7c8b3a47

Freund, B., Colgrove, L. A. , Petrakos, D. , & McLeod, R. (2008) In my car the brake is on the right: Pedal errors among older drivers. Accident Analysis & Prevention, 40 (1), 403-409.

Hannah, R., Folland, J. P., Smith, S. L., & Minshull, C. (2015). Explosive hamstrings-to

quadriceps force ratio of males versus females. *European Journal of Applied Physiology, 115*(4), 837847. https://doi.org/10.1007/s00421-014-3063-y

Kirschbaum, S., Fuchs, M., Otto, M., Gwinner, C., Perka, C., Sentürk, U., & Pfitzner, T. (2021). Reaction time and brake pedal force after total knee replacement: Timeframe for return to car driving. *Knee Surgery, Sports Traumatology, Arthroscopy : Official Journal of the ESSKA, 29*(10), 3213-3220. https://doi.org/10.1007/s00167-020-06105-2

Older drivers. Injury Facts. (2022, May 2). Retrieved May 15, 2022, from https://injuryfacts.nsc.org/motor-vehicle/road-users/older-drivers/#:~:text=NHTSA%20estimates%20that%20the%20majority,older%20driver%3A%20533%20(7.5%25)

Vance, D. E. (2009) Speed of processing in older adults: a cognitive overview for nursing. Journal of Neuroscience Nursing, 41(6), 29.