PROJECT TITLE: Reaction Time and Mobility Testing in a Cross-Canada Population of Older Drivers

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SUMMARY:

Older drivers over the age of 70 are a rapidly growing part of the Canadian population, and increasing driver age is associated with a higher prevalence of and morbidity in motor vehicle accidents. Current driver evaluation guidelines for physicians are insufficient, and individual driver testing is costly. This study, as a part of the Canadian Driving Research Initiative for Vehicular Safety in the Elderly (Candrive), examined results from several reaction time and mobility tests, conducted on older drivers from seven sites across Canada. The testing protocols used in this study were analyzed for validity and reliability, and testing performance was analyzed to determine whether relationships exist between aging, physical and cognitive performance, and driver crash risk. This study found that the Vericom Reaction Timer was a reliable and valid test for reaction time, while the Ruler Drop Test was not. Longitudinal data showed that aging may affect lower body mobility. Analysis of past MVA data showed no differences in physical performance testing between crashing and non-crashing individuals.

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Student's Signature **Supervisor's Signature**

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Introduction

Over 13% of Canadians today are 65 years of age or older, and this group is the fastest growing population in the country[1]. Out of the approximately 4.4 million Canadian seniors, 50% of those living independently in the community drive a motor vehicle, mostly for short social trips and errands[2].

However, numerous studies have shown that older drivers are at an increased risk for motor vehicle accidents (MVAs), and experience the highest rate of fatalities, the causes of which are largely attributed to aging processes[3,4,5,6,7]. While healthy aging is associated with physical and functional atrophy in many areas of the brain, aging is also associated with the highest prevalence of chronic diseases[8,9,10]. Chronic diseases impair mobility and also lead to the highest rate of usage of prescription, over-the-counter, and alternative medicines in the Canadian population; 76% of seniors living in the community use at least one medication, and 13% take five or more different medications[11,12,13,14].

In Canada and the US, it is largely the primary care physician's responsibility to recognize when their older patients may no longer be driving safely. Although both the Canadian and American Medical Associations have published guidelines regarding physician screening of patient driving ability, the Canadian Medical Association Driver's Guide, 7th edition, states that no specific testing method has been recommended due to the lack of supporting evidence[15, 16]. Upon being reported as possibly being unfit to drive, patients must undergo a $400-$500 driving assessments, the cost of which is not covered by many provincial health systems. The financial costs to the patient and absence of effective screening procedures available to physicians act as deterrents for the medical community to report unfit drivers – a Canada-wide survey of four hundred sixty physicians found 45% of them not confident in assessing driving fitness [17].

Candrive Study

In response to the potential dangers of older drivers and physician under-reporting, the Canadian Driving Research Initiative for Vehicular Safety in the Elderly (Candrive) has spearheaded a cross-Canada, 5 year longitudinal study examining predictors of crash risk, in order to improve the safety of older drivers. One goal of the Candrive initiative is to develop a reliable screening tool, feasible in a clinical setting, to detect unfit drivers and improve physician confidence and appropriate reporting of unfit drivers. By evaluating senior drivers using cognitive and functional assessment tools, the Candrive study aims to establish correlations between measurable parameters and a driver's future crash risk.

As a part of this larger study, this present project aimed to examine the relationship between reaction time, lower body mobility, and an older driver's crash risk. Specifically, this project had 4 objectives:

1. To determine the validity and reliability of the reaction time and mobility tests used in the study, using a small, separate sample of participants in Winnipeg.
2. To determine the validity of the reaction time and mobility tests using baseline data collected from participants of the cross-Canada Candrive study.

3. To examine any longitudinal trends in testing performance present in data collected from the Winnipeg Candrive participants over two years.
4. To conduct a preliminary study detecting differences in physical testing performance between participants who have experienced crashes (all crashes as well as at-fault) versus those who have not, using data from the Winnipeg Candrive participants.

Gait Speed

Gait speed has been a well-studied measure of the effect of aging on lower body physical performance, with numerous studies examining its association with processes ranging from general health, high blood pressure, and depression, to activities of daily living (ADLs), risk of falls, and driving crash risk[18,19,20]. Most pertinent to this study, several studies have examined the role of gait speed testing as part of a fitness-to-drive testing panel, and found that gait speed showed high correlation with clinically assessed driving ability[21,22], and was predictive of future crash risk[23,24,25] .

The evaluation of gait speed has been performed using several different protocols, all involving participants walking a set distance while being timed. The distance used varies largely between studies, from 10 feet to 40 feet [18,19,20,21,22,23,24,25]In the present study, the 20 feet Rapid Pace Walk Test was chosen, as described by the American Medical Association[16], since its short distance and duration of test were most feasible in a clinical setting. In previous evaluations of the Rapid Pace Walk Test, it was found that results greater than 7 seconds were associated with an increased risk of a driving incident, such as a crash or traffic ticket[21].The American Medical association currently cites 9 seconds as the cutoff at which an intervention is warranted[16].

Vericom Reaction Time Tests

It has been previously established in an all-female cohort that increased foot reaction time was highly predictive of crash risk[25]. The Vericom Stationary Reaction Timer (Vericom Computers, 2003) is a computer-based program that measures reaction time while subjects simulate driving using the attached steering wheel and brake and gas pedals. The Vericom system measures simple reaction time using the Hard Brake Test, in which subjects must brake as fast as possible in response to a stimulus on the computer screen. Choice reaction time is tested using the Turning test, in which subjects must turn the steering wheel as fast as possible to the corresponding direction when prompted by an on-screen stimulus.

The Vericom system is a novel system which has not been previously studied. While its setup is not feasible in a physician's office, it may be a useful tool in investigating the correlation between reaction time and driving performance. Subsequently, other simpler tests may be devised based on current findings, which can be used by physicians to assess fitness to drive.

Ruler Drop Test

A version of the Ruler Drop Test was first described by Pieron in 1928, and termed by Woodsworth and Schlosberg in 1954 as the "simplest chronoscope"[26,27]. Since then, the

Ruler Drop test has been regarded as measure of simple reaction time[28], and is used largely in recreational sports testing. Currently, no studies have been completed to investigate the relationship of the Ruler Drop test to other physical activity performances, including driving. The Ruler Drop test is an attractive option for measuring simple reaction time, as it is safe, cost-effective, and requires minimal skill on the part of both the tester and subject to complete.

Lafayette Reaction Time Test

In a previous study[28], the Lafayette Reaction Timer was found to be a very reliable measurement of reaction time, and is therefore used as the gold standard of reaction time measurement in the reliability and validity analysis. The Lafayette Reaction Timer is a mechanized reaction timer that measures the time needed for subjects to brake quickly in response to a stimulus light.

Candrive Test Panel

The Vericom Reaction Time Tests, Ruler Drop Test, and Rapid Pace Walk Test analyzed in this study were administered as part of a battery of cognitive and physical tests specified by the Candrive protocol. The Candrive battery of tests began with a tester-administered questionnaire which collected demographic, health, and current driving information. Physical and cognitive tests were then performed, and included, in addition to the aforementioned tests, evaluations of cognitive status, range of motion and strength testing, sensory tests including vision and hearing, and physical coordination testing. Following these tests, subjects were given a self-administered questionnaire which evaluated the subject's mood and self-perceptions of driving ability. The driving behavior of each subject was also monitored by an in-car GPS device.

Hypothesis

It is hypothesized that the Vericom Reaction Timer and the Ruler Drop test are valid and reliable predictors of reaction time. Due to effects of aging, the performance on reaction time and mobility tests are expected to become slower over the two years. As the comparison of the testing performances between subjects who have and have not crashed is a preliminary examination with a small sample size, no conclusive trends are expected to arise from this study.

Methods

Participants

A. Reliability and validity study using a separate Winnipeg participant pool

Seventeen older drivers (5 females, 12 males) were recruited through the Winnipeg sample of participants who did not qualify for the Candrive study, but had expressed interest in participating in future studies. Upon recruitment, subjects received an information package detailing the study, as well as an Intake and Medical Questionnaire. The age range of the participants was 70-89 years, with a mean of 75.8 $\pm$ 5.0 years. Exclusionary criteria included driving less than once per week, no valid Class 5 Driver's License, and unstable medical conditions.

B. Validity study using cross-Canada Candrive subjects
For the Candrive study, 933 older drivers (aged 70 and older) were enrolled across Canada at seven different testing sites (Victoria, Winnipeg, Thunder Bay, Ottawa, Hamilton, Toronto, and Montreal). Inclusion criteria were followed as specified by the Candrive protocol, and included being 70 years of age or older, having a valid class 5 driver's license, driving a car modeled 1996 or newer, and having no unstable health conditions. The age range of participants at recruitment was 70-94 years, with a mean of 76 $\pm$ 4.9 years. The participants included 581 males and 352 females .

Upon enrollment into the study, subjects received an information package containing details of the study as well as consent forms for testing. The subjects were informed that should their results of the study meet any absolute contraindications to driving, their family physicians would be contacted.

C. Longitudinal study and crash data comparison
As a part of the Candrive subject pool, 125 participants were enrolled at the Winnipeg site, using the same inclusion criteria as specified by the Candrive protocol. The participants included 38 females and 87 males, and the age range of participants was 70-89 years, with a mean of 75.3 $\pm$ 4.8 years.

Reliability and Validity Study
For the separate Winnipeg participant pool, subjects were tested using the Vericom Reaction Time Tests, the Ruler Drop Test, the Rapid Pace Walk Test, and the Lafayette Reaction Time Test. They were retested one week later, at which time the testing order was reversed.

The Candrive validity data was collected during the Candrive Testing Panel, as described below.

Lafayette Reaction Time Test
Participants were instructed to move their foot as quickly as possible from the gas to the brake pedal when they saw the red light. They were told to watch the white warning light, which would shut off before the red brake light turned on. The time lag between the warning and brake lights was manually altered according to a set sequence. The reaction time and total movement time were recorded. Ten practice trials were conducted before the ten actual trials.

Vericom Reaction Time Tests
For the Hard Brake Test, the participants were instructed to transfer their right foot from the gas to the brake pedal and brake as soon as a computer-randomized red light appeared on the screen. Ten practice trials were conducted before ten actual trials for each test. For the Turning test, participants were instructed to depress the gas pedal and hold the steering wheel with both hands. When the orange light appeared, they turned fully as quickly as possible in the direction of the light. In the event of a wrong turn, they were told to correct themselves as quickly as possible. Ten practice trials were conducted before ten actual trials for each test.

From the Vericom Hard Brake data, the Foot Movement Time was calculated, which represented the time lapsed from the initial release of the gas pedal to the initial depression of the brake pedal. The Simple Reaction Time was calculated by subtracting the Foot Movement Time from the Total Reaction Time, and equals the time needed for the subject to release the gas pedal in response to the stimulus. For all Vericom data, mean reaction times for each subject were calculated. Within each raw data set for each participant, reaction times greater or less than two standard deviations from the mean were excluded.

Ruler Drop Test
Participants were seated in a chair, with their dominant (catching) hand resting on the armrest, and the thumb and forefinger placed the same width apart as a 30cm long plastic ruler. The ruler was positioned with the 0 cm mark at the top edge of the thumb. Participants were asked to catch the ruler with thumb and forefinger without wrist movement, without any warning being given. Five trials were conducted after 3 practice trials, and the position of the top of the thumb was recorded after each successful catch, rounded to the nearest half-centimeter. In the event of a failed catch, the value 31cm was assigned to the trial. For statistical analysis of the Ruler Drop data, the median value was used to eliminate any data skewing by anticipation.

Rapid Pace Walk Test
A 10-foot path was demarcated on the floor with tape at the start and the 10-foot lines. Participants were instructed to walk as quickly as possible to the 10-foot line, turn around as safely as possible on both feet, then return to the start as quickly as possible. To time the test, the stopwatch was started when the participant first lifted up one foot, and stopped when one foot crossed the finish line. One trial was conducted for each participant.

Historical Crash Data
Upon receiving consent from participants, information was obtained from Manitoba Public Insurance regarding reported motor vehicle crashes from the two years prior to the subject's enrollment in this study. The information included whether the driver was at-fault, the location of the crash, and the purpose of the trip.

Data and Statistical Analyses
All data were analyzed using SigmaPlot (version 11.0). The validity and reliability data were also examined using SPSS (version 11.0.0). Statistical significance was set at a p value of 0.05.

Validity and Reliability
The Lafayette Foot Movement Time and the Vericom Foot Movement Time were calculated by subtracting the reaction time from the combined movement time.

The means and standard deviations were calculated from the actual trials of each subject for sessions 1 and 2. The paired t-test was used to detect significant systematic change between sessions, and the Pearson correlation coefficient was calculated from the means to assess relationships between sessions. The ICC (Intraclass Correlation) was calculated to detect systematic and random error. For all of the data except the Rapid Pace Walk Test, the average measure value of the ICC was obtained. The single measure value of the ICC was obtained for the Rapid Pace Walk Test, since only one trial was performed. Bland-Altman plots were constructed to visually detect data trends. Absolute reliability was evaluated through calculating the CV (Coefficient of Variation).

To examine validity, linear regression was performed using Lafayette Combined and Foot Movement Time, Vericom Hard Brake and Turning Tests, and the Ruler Drop Test. The validity study conducted using Candrive data utilized linear regression to compare the Vericom Reaction Time Tests, the Ruler Drop Test, and the Rapid Pace Walk Test.

Longitudinal data
Longitudinal data from baseline and year 2 obtained at the Winnipeg site were analyzed using a paired t-test to detect changes over time.

Crash data analysis
T-tests were conducted to detect differences between the reaction time and mobility testing performances of subjects who have been involved in motor vehicle crashes in the past 5 years, versus those who have not.

<u>Results</u>

Validity and Reliability Study – Separate Winnipeg Participant Pool
The means and standard deviations from the Lafayette, Vericom, Ruler Drop, and Rapid Pace Walk tests are presented in Table 1. Results from the paired T-test are included indicating presence of significant change from test 1 to test 2. There were no significant changes between test 1 and test 2, except in the Vericom Hard Brake Test, in which participants appeared to have improved reaction time in test 2 ($p<0.05$).

The reliability data for all reaction time and walking tests are presented in Table 2. The Vericom Hard Brake Test and the Rapid Pace Walk Test demonstrated the highest ICCs. The Vericom Hard Brake Test also demonstrated the lowest CV (7.7%), indicating highest absolute reliability. Meanwhile, the Lafayette Foot Movement Time demonstrated the highest variability with a CV of 17.8%. The Pearson correlation coefficient (R) indicated that all data demonstrated significant positive correlation except for the Lafayette Foot Reaction Time ($p=0.12$).

Bland-Altman plots (Figure 1) were constructed with differences of the means of test 1 and test 2 for each subject plotted against the individual means of the two tests for each subject. The mean difference and 95% confidence intervals are indicated on each graph. This was performed for all tests to visually examine the reliability data for systematic bias and heteroscedasticity. The Lafayette Reaction Time test demonstrated good agreement between sessions for lower means, but heteroscedasticity was observed. The Lafayette Foot Movement Time, Vericom Hard Brake, and Ruler Drop tests were variable with outliers. In contrast, the Vericom Turning test and Rapid Pace Walk Test showed agreement between sessions.

Linear regression analyses data is reported in Table 3. A statistically significant correlation was found only between the Lafayette Reaction Time test and the Vericom Hard Brake test, while no significant relationship was found using the Ruler Drop Test.

Validity Study – Cross-Canada Candrive Participants

Linear regression analyses using data collected from all seven Candrive sites found a statistically significant relationship between the Ruler Drop Test and the Hard Brake Test, with an R-value of 0.08 ($p=0.039$). No significant relationship was found between the Ruler Drop Test and the Vericom Turning Test ($R=0.05$, $p=0.173$). For the Rapid Pace Walk Test, no significant relationships were found with respect to the Vericom Hard Brake Test ($R=0.02$, $p=0.552$) nor the Vericom Turning Test ($R=0.07$, $p=0.054$).

Longitudinal data

The means, percent change, and standard deviations from the Vericom Reaction Time Tests and the Ruler Drop Test are presented in Table 4. Paired t-tests demonstrated that the Vericom Turning Test and Ruler Drop Test significantly improved between year 1 and year 2. While the Vericom Hard Brake Test showed no difference between year 1 and year 2, the two values derived from the Hard Brake Test differed between year 1 and 2, with Foot Movement Time becoming slower, while Simple Reaction Time improved. The Rapid Pace Walk test also slowed from year 1 to 2.

Crash Data Analysis

Thirty-three subjects experienced motor vehicle accidents (MVAs) in the past five years, with 24 recorded as at-fault crashes. P-values from t-tests are presented in Table 5. No significant differences were found between groups experiencing MVAs versus those who did not.

Discussion

There were four aims in this study: to determine the validity and reliability of the reaction time and mobility tests in a small Winnipeg participant population, to determine the validity of the reaction time tests using the larger Candrive population, to observe data trends longitudinally, and finally to detect differences in testing performance between subjects who were or were not involved in past crashes. The overall goal of this study, as a part of the Candrive Initiative, was to develop clinically feasible screening tests to determine an older driver's fitness to drive.

In the design of the Candrive study, seven testing sites across Canada were chosen; Victoria, Winnipeg, Thunder Bay, Ottawa, Hamilton, Toronto, and Montreal. Analysis of reaction time and mobility test data from the sites showed that overall, there was variability between sites. With each testing site having different testers and equipment, it is conceivable that these differences contributed to the variability in data. In addition, as not all subjects were tested on the same day, it is possible that other confounding factors may have influenced subject performance. For example, it has been well established that arousal significantly influences reaction time[29]; thus, depending on the amount of time a tester requires to conduct the full Candrive battery, as well as other extrinsic factors, subjects from certain sites may have altered levels of arousal during testing. Recently, a study found that older subjects are more likely to err in stepping reaction time tests, such as the Vericom, as a result of the effects of aging on central motor processing[30]. This effect is most pronounced in choice reaction time tests, and could contribute to the variability in both Vericom Reaction Time Tests. Finally, differences in demographic distribution, such as certain sites having a younger subject population or different gender distribution may contribute to differences in performance. To reduce the variability observed, it may be beneficial to increase tester training that emphasizes strict adherence to the written protocol, as well as consistent use of identical equipment for testing.

Validity and Reliability Data – separate Winnipeg participants
This study employed many tests that have not been analyzed in previous literature, and so it was essential to determine the reliability and validity of the Ruler Drop Test, the Rapid Pace Walk Test, and the Vericom Reaction Time Test. Individually, each test appeared absolutely and relatively reliable. As the Vericom Reaction Time Test demonstrated a small change between the two sessions, it indicates that testers should account for the change when interpreting results. Meanwhile, the longitudinal data found no change in the Vericom Hard Brake Test, but a greater change than the reliability data in the Vericom Turning Test. This variation in test performance behavior between the reliability and longitudinal studies may be due to the longer one-year rest period between testing in the Candrive study, and it appears that time elapsed between tests may be a confounding factor in reaction time testing performance trends. The change in performance found in the longitudinal data is discussed below.

Despite being the gold standard, the Lafayette Equipment-Based Test was the most variable, and weekly sessions were not significantly positively correlated. The data also demonstrated increased variability with higher reaction times. This differed from another study, which found the Lafayette test to be very reliable[28]. The results from this study may be a reflection of a mechanical problem encountered with the testing equipment, specifically the pedal switches, during this particular study.
While the Vericom Reaction Time Test was found to be a valid predictor of reaction time, the Ruler Drop Test was not. It could be inferred that the Ruler Drop Test tests not only simple reaction time, but also hand dexterity and coordination. In addition, it was difficult for the tester to maintain consistency in the testing procedure between trials and sessions.

Validity – Candrive data
In using a much larger sample size to conduct validity analysis, a statistically significant relationship was found between the Ruler Drop Test and the Vericom Hard Brake Test. However, the very small R-value indicates that although statistically this relationship is significant, the clinical relevance of this relationship is insignificant. Therefore, the results from this study confirmed with a great degree of confidence the findings above; that the Ruler Drop Test is not a valid representation of reaction time, as a result of the confounding factors described above.

The Rapid Pace Walk Test was also not related to either of the Vericom Reaction Time Tests. While the Hard Brake Test contained an aspect of lower body mobility, as represented by the Foot Movement Time, the Vericom tests is nevertheless a test of reaction time; meanwhile, the Rapid Pace Walk Test is largely a test of lower body mobility. As different parameters are measured, and possibly influenced to different extents by aging, it is reasonable to find that they are not linearly related.

Longitudinal Data

The longitudinal data from Winnipeg was collected over two years. From baseline to year two, changes in performance were observed for nearly all of the tests. A previous study examining the usefulness of longitudinal testing found that performance changes due to aging may be confounded by retest effects, i.e., previous exposure to material, resulting in decreased testing anxiety and improved performance[31]. It is plausible that subjects in this experiment experienced similar effects. The tests used in this study were particularly vulnerable to retest effects, due to two conditions: for the Ruler Drop test, the simplicity and novelty of the experiment potentially allowed subjects to easily replicate the test at home, facilitating practice outside of testing times and increasing awareness of performance when encountering similar activities. Thus, a learning effect could have contributed to performance enhancement. For the Vericom test, in particular the Turning Test, because many of the older drivers were unfamiliar with the technology and equipment, testing anxiety during year 1 may have adversely affected reaction time. This anxiety may have been reduced in year 2, as subjects became more familiar with the testing regime. Since improvements in testing performance was observed longitudinally in both the Ruler Drop and the Vericom Turning Test, retest effects could have influenced both sets of data.

The Vericom Foot Movement Time and the Rapid Pace Walk Test can both be used to represent lower body mobility, and is more dependent on physical performance than the reaction time tests. As both tests showed a significant slowing from baseline to year 2, it is suggestive that, consistent with previous studies, aging was associated with a decrease in lower body mobility[32].

While the Vericom Foot Movement Time slowed over time, the overall Total Reaction Time from the Hard Brake Test did not change. This was due to the compensation from the behavior of the Simple Reaction Time, which improved over the two years. This improvement of the Simple Reaction Time may again be due to retest effects, as discussed above, with the subjects gaining confidence using unfamiliar equipment over time. Alternatively, because Simple Reaction Time, the Turning Test, and the Ruler Drop Test are all evaluations of central cognitive processes, the results may be suggestive that short-term aging over one year does not adversely affect its performance; rather, such stimulation from testing may actually be beneficial.

To further elucidate the effects of aging using longitudinal data, the same data should be collected over more years, at which time the retest effect should decrease to a minimum as subjects’ confidence with the testing regime maximize. Indeed, the Candrive study will be carried out for 5 years, and is expected to be more informative regarding the effects of aging on physical and mental performance.

Crash Data Analysis

In this study, the examination of between reaction time performance, mobility testing, and crash risk was a preliminary analysis, with a very small sample size. While no significant were found the larger Candrive study may be informative in the future, when the testing performance of the larger study population is compared to longitudinal driving data, as measured by the in-car GPS device. While the larger study expects to establish relationships between physical performance and driving, an absence of relationships, as found in this study, may also be informative.The apparent independence of reaction time performance, mobility, and crash risk found in this preliminary study may suggest the complexity of driving, and carries implications that perhaps clinically feasible testing may be too simple to accurately reflect the broad range of abilities required to drive safely. Alternatively, these results may suggest that current driver testing batteries, which incorporate reaction time and mobility testing, may not be as effective as possible, as these tests may be extraneous, and other more informative tests are not being utilized.

Conclusion

This study showed that the Vericom Reaction Time tests used in the study are reliable and a valid representation of reaction time. However, the Ruler Drop Test was not found to be a valid test of reaction time, and Rapid Pace Walk Test was also not related to the Vericom tests. The data demonstrated that longitudinally, aging may decrease lower body mobility. Further, a preliminary analysis of the testing differences between crashing and non-crashing older drivers showed no differences. This study demonstrated that the Vericom Reaction Time test may yet be a novel, useful tool for measuring reaction time, and warrants further investigation to determine its role in older driver testing. More broadly, as the safety of older drivers becomes an increasing concern in Canadian society, it is imperative that studies such as the Candrive initiative investigate and develop feasible and accurate testing batteries to positively determine the ability of older drivers.

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Tables and Figures

Table 1. Means, standard deviation, and paired t-test for reaction time and mobility tests from separate Winnipeg participants.

Test	Mean and Standard Deviation		P Value From Paired T-Test
	Test 1	Test 2	
Lafayette Foot Reaction Time	0.331 ± 0.043	0.317 ± 0.030	0.203
Lafayette Foot Movement Time	0.151 ± 0.363	0.154 ± 0.010	0.744
Lafayette Combined Movement Time	0.482 ± 0.064	0.472 ± 0.059	0.514
Vericom Hard Brake Test	0.53 ± 0.08	0.49 ± 0.07	0.004
Vericom Turning Test	0.53± 0.10	0.49 ± 0.06	0.114
Ruler Drop test	18.9 ± 3.7	20.8 ± 3.3	0.096
Rapid Pace Walk Test	5.5 ± 1.4	5.5 ± 1.3	1.000

Table 2. Relative and absolute reliability scores for reaction time and mobility tests.

Test	ICC	95% CI for ICC	CV (%)	R^{α}
Lafayette Foot Reaction Time	0.54	-0.28 – 0.83	9.0	0.39 (p = 0.12)
Lafayette Foot Movement Time	0.69	0.13-0.89	17.8	0.53 (p =0.03)
Lafayette Combined Movement Time	0.65	0.03-0.87	9.3	0.48 (p=0.05)
Vericom Hard Brake Test	0.83	0.53-0.94	7.7	0.72 (p =0.00)
Vericom Turning Test	0.69	0.15-0.89	11.2	0.58 (p =0.01)
Ruler Drop test	0.76	0.34-0.91	11.1	0.62 (p =0.02)
Rapid Pace Walk Test	0.87	0.68-0.95	9.1	0.87 (p =0.00)

α R and p values from Pearson Correlation Analysis

Table 3. Linear regression scores of reaction time and ruler drop tests from separate Winnipeg participants

Test		R
Dependent Variable	**Independent Variable**	
Lafayette Combined Time	Vericom Hard Brake	0.66 (p=0.004)
Ruler Drop Test	Vericom Hard Brake	0.35 (p=0.168)
Ruler Drop Test	Vericom Turning	0.13 (p=0.625)
Ruler Drop Test	Lafayette Combined Time	0.41 (p=0.100)
Ruler Drop Test	Lafayette Reaction Time	0.43 (p=0.085)

Table 4. Longitudinal analysis of means, standard deviation, difference, and paired t-test for reaction time, mobility, and ruler drop tests

Test	**Mean and Standard Deviation**		**% Change from Year 1 to 2**	**P Value from Paired T-test**
	Year 1	**Year 2**		
Vericom Simple Reaction Time (Hard Brake)	0.375 ±0.06	0.351 ± 0.05	-6.4%	<0.001
Vericom Foot Movement Time (Hard Brake)	0.162 ± 0.03	0.187 ± 0.05	15.4%	<0.001
Vericom Total Reaction Time (Hard Brake)	0.54 ± 0.07	0.54 ± 0.08	0%	0.866
Vericom Turning Test	0.54 ± 0.09	0.53 ± 0.06	-1.9%	0.028
Ruler Drop Test	25.7 ± 3.8	24.1 ± 3.7	-6.2%	<0.001
Rapid Pace Walk Test	5.7 ± 1.6	5.9 ± 1.4	3.6%	0.029

Table 5. T-test analysis between variables and historical crash data

Variable	**Means/Distribution**				**p-value with All Crash Data**	**p-value with At-fault Crash data**
	All crashes (n = 33)	At-fault crashes (n = 24)	No crashes (n = 90)	No at-fault crashes (n = 99)		
Simple Reaction Time	0.36 ± 0.04	0.37 ± 0.04	0.38 ± 0.06	0.38 ± 0.06	0.212	0.658
Foot Movement Time	0.16 ± 0.03	0.16 ± 0.03	0.16 ± 0.04	0.16 ± 0.04	0.517	0.687
Total Hard Brake Reaction Time	0.52 ± 0.04	0.53 ± 0.05	0.54 ± 0.07	0.53 ± 0.07	0.228	0.974
Turning Reaction Time	0.52 ± 0.08	0.53 ± 0.08	0.55 ± 0.09	0.54 ± 0.09	0.113	0.368
Ruler Drop	24.7± 4.4	25.0± 4.3	25.6 ± 4.0	25.5 ± 4.0	0.277	0.584
Rapid Pace Walk Test	5.6 ± 1.1	5.5 ± 1.1	5.7± 1.8	5.8 ± 1.7	0.673	0.482

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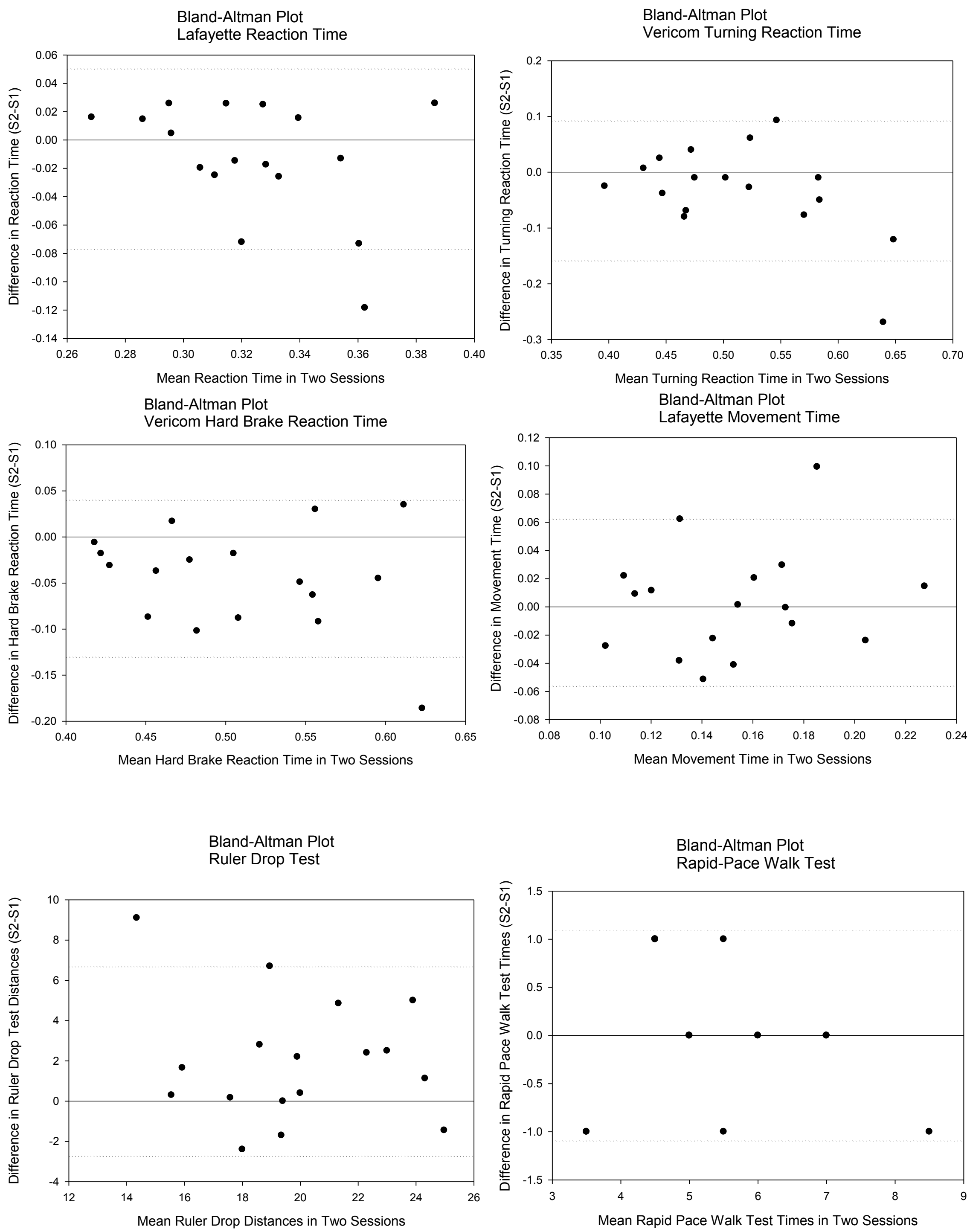

Figure 1. Bland Altman plots of all the tests, whereby the mean of the two sessions is the x axis and the y axis is the difference between session 1 and 2 (i.e., session 2 – session 1). The solid lines are zero, and the dashed lines are the 95% confidence intervals.