Brake Response Time in Diabetic Patients with Lower Extremity Neuropathy

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Statement of Purpose and Literature Review

The presentation of diabetic neuropathy is as a symmetrical sensorimotor polyneuropathy preferentially affecting the lower extremities. The most apparent effects of this occur within the sensory system and contribute to the development of pedal ulcerations, lower extremity infection, and both minor and major limb amputations. However, involvement of the motor system also carries the potential for significant clinical pathology. Lower extremity weakness, muscular atrophy, slowing of movements, unstable gait and an increased frequency of falls have all been associated with diabetic motor neuropathy. Additionally, and distinct from the lower extremity, general auditory and visual reaction times have been demonstrated to be impaired in the presence of diabetes.

Further, the effect of lower extremity pathology and surgical intervention on driving function and brake response times has been a topic of contemporary interest within the medical literature. Several authors have published general guidelines about the return to driving following elective and non-elective lower extremity surgery, while others have specifically studied the effect of chronic musculoskeletal lower extremity pathology and immobilization devices on driving outcomes. Despite this, we are unaware of any specific analysis into the effects of diabetic neuropathy and diabetic foot disease on driving parameters.

The objective of this investigation was to assess brake response times in diabetics with neuropathy. We aimed to determine whether diabetics with neuropathy have slower brake reaction times than normative values and published safety thresholds.

Methodology

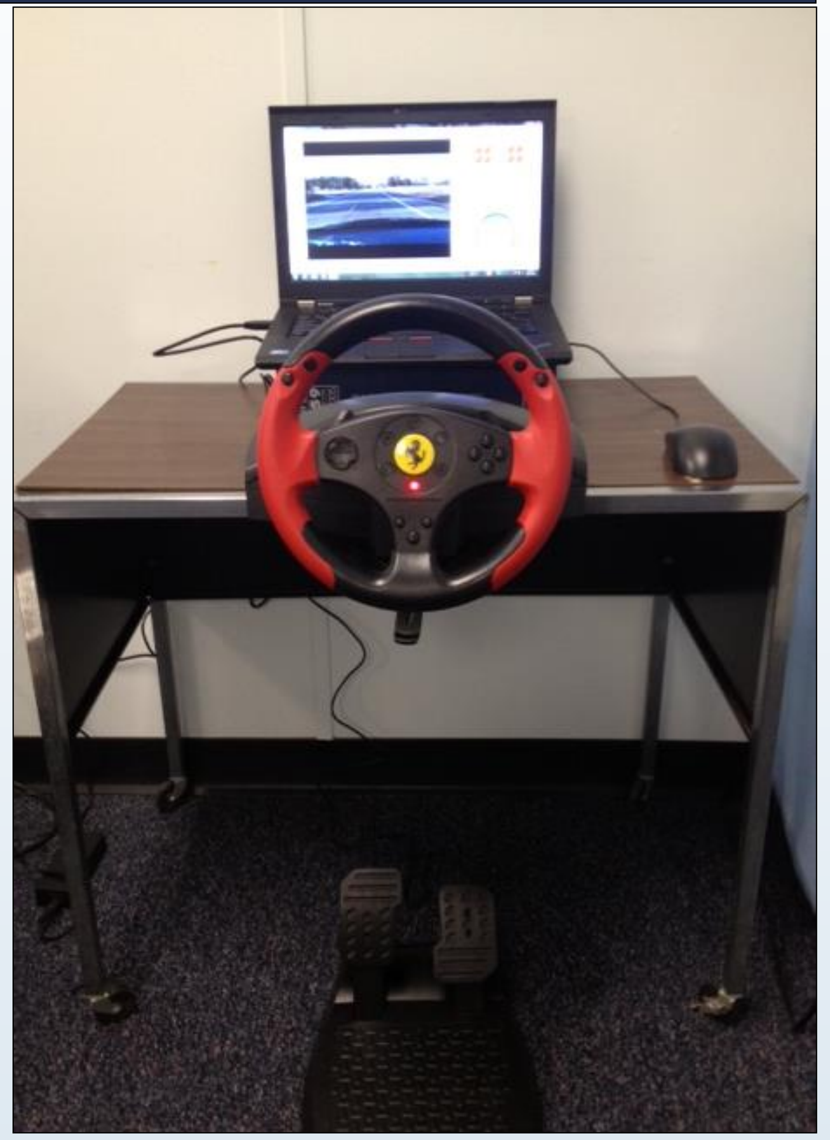
The braking performances of participants was evaluated with a computerized driving simulator (Stationary Simple Reaction Timer, Vericom Computers, Inc, Rogers, MN) which has previously been used to evaluate driving reaction times in the setting of lower extremity impairment. The simulator consists of a laptop computer, steering wheel, accelerator and brake pedal system (Figure 1). Participants were seated in a comfortable position with adjustment of the foot pedals and steering wheel as needed for individual comfort. The accelerator pedal was initially depressed with their right foot until a constant speed was maintained. Then, at a random time within a ten second window, a red light was activated on the screen at which time the participant depressed the brake pedal as quickly as they could. The time interval between the red light activation and initiation of brake pedal depression was recorded as the brake response time.

Verbal instructions on how to use the simulator were given and participants had the opportunity to undergo practice trials prior to the actual brake response testing until they felt comfortable with the equipment. Ten trials were then performed for each participant, with elimination of the fastest and slowest trials for each set prior to data analysis. The primary outcome measure was the mean brake response time from the eight recorded trials.

There are some published reports with respect to normal and abnormal brake response times. Although a meta-analysis has demonstrated a relatively large range in reported brake response times, several investigations and the United States Federal Highway Administration have reported a cut-off threshold for potentially unsafe brake response times at 0.700 seconds and normal value of approximately 0.500 seconds. Based on this work, we chose to use 0.700 seconds as a cut-off for potentially unsafe brake response times in this investigation based on these studies. We considered brake reaction times < 0.700 seconds as normal, and those ≥ 0.700 seconds as abnormally "slow".

Inclusion criteria of study participants consisted of patients diagnosed with diabetes, with a recent (<6 months) hemoglobin A1c value, the presence of lower extremity neuropathy, and who defined themselves as active drivers. Neuropathy was defined utilizing the Michigan Neuropathy Screening Instrument (MNSI) which is a validated measure of diabetic neuropathy encompassing sensory, motor and autonomic components. The maximum score available is 5 points for each limb and 10 points total for both limbs, with a score of ≥ 2.5 defining neuropathy.

A direct statistical comparison of mean brake response times of the neuropathic group was performed to a control group of active drivers without neuropathy, in addition to a comparison of the frequency of "slow" reactions between groups.



Results

Table 1: Outcome measure results.
The primary outcome measure of this investigation was mean brake response time compared between a control group of drivers with neither diabetes nor neuropathy (n=25 subjects; 200 driving trials) and drivers with diabetes and neuropathy (n=10 subjects; 80 driving trials). A secondary analysis of frequency of "slow" brake response trials (defined as ≥ 0.700 seconds) was additionally performed.

	Drivers without diabetes or lower extremity neuropathy (control; n=200 trials)	Drivers with diabetes and lower extremity neuropathy (experimental; n= 80 trials)	Statistical comparison
Mean Brake Response time (seconds)	**0.55 ± 0.08**	**0.71 ± 0.08**	**p < 0.0001** (unpaired t-test)
Frequency of "slow" reactions (≥ 0.700 seconds)	**6/200 (3.0%)**	**41/80 (51.3%)**	**p < 0.0001** (Fisher's exact test)

A control group consisted of 25 subjects (13 male; mean age 32.7 years) and 200 brake response trials. The mean brake response time observed was 0.549 ± 0.076 seconds. An abnormally "slow" brake response time was observed in 6 (3.0%) of the 200 trials.

An experimental group consisted of 10 subjects (10 male; mean age 57.5 years) and 80 brake response trials. All were diabetic with a mean MNSI score of 6.2 (range 2.5-8). The mean brake response time observed was 0.710 ± 0.076 seconds. An abnormally "slow" brake response time was observed in 41 (51.3%) of 80 the trials.

The experimental group of neuropathic diabetics demonstrated a statistically slower mean brake response time (0.710 vs. 0.549 seconds; p<0.0001), with "slow" reactions occurring at a greater frequency (51.3% vs. 3.0%; p<0.0001).

Discussion

As with any scientific investigation, critical readers are encouraged to review the study design and results and reach their own conclusions, while the following represents our conclusions based on the specific results. As scientists, we also never consider data to be definitive, but do think that these results are worthy of attention and future investigation.

-We think that the results of this investigation demonstrate both clinically and statistically significant findings. **Diabetic drivers with neuropathy demonstrated slower mean brake response times and had an increased frequency of "slow" brake reactions**. Although this difference was statistically significant in comparison to a control group, we think these findings are clinically significant even without a statistical comparison. **The mean observed brake response time in neuropathic diabetics was slower than an accepted threshold reported by sources including the United States Federal Highway Administration, and we observed "slow" brake responses above this threshold in the majority of braking trials involving neuropathic diabetics.** We thought that these were frankly eye-opening findings that have the potential to affect millions of drivers in the United States and worldwide.

Some important limiting considerations….

-Brake response time represents only a single facet of total driving function. Just because brake response times are slow, does not mean that neuropathic diabetic drivers are necessarily at an increased risk for traffic accidents. For example, elderly drivers have been generally observed to unconsciously compensate for decreased reaction times associated with age by driving at slower speeds and following vehicles at greater distances. Our intention is not for this data to be considered definitive, but rather introductory in nature and hopefully as the first of many future investigations into diabetic driving function.

-Our experimental group should be considered pilot data at this point (n=10). Although the observed statistically significant findings are of adequate power, it is our intention to collect data on at least 25 experimental subjects and further attempt to evaluate if any specific component (the diagnosis of diabetes alone, the diagnosis of neuropathy alone, complications of diabetes including wounds/amputations/Charcot neuropathy) plays a significant contributing role in driving function.

In conclusion, the results of this investigation provide unique data with respect to decreased brake response times and potentially impaired driving function in diabetics with lower extremity neuropathy.

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