Original Article

Association between cognition, gait speed and vehicle habilitation in elderly people

Associação entre cognição, velocidade da marcha e habilitação veicular em idosos

Relación entre cognición, velocidad de la marcha y licencia de conducir en adultos mayores

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Abstract

Objective: To investigate the association between cognition, gait speed and the result of vehicle habilitation of elderly candidates for the National Driver's License.

Methods: Quantitative cross-sectional study developed in 12 traffic agencies in Curitiba, state of Paraná, Brazil. The probabilistic sample consisted of 421 elderly people ($\geq$ 60 years). The Mini-Mental State Examination (MMSE), gait speed testing and consultations to forms of the National Qualified Drivers Registration were used for data collection. The relationship between variables was identified through the multiple linear regression test, stepwise method, using the statistical program R, version 3.4.0.

Results: When increasing a unit in the MMSE score, the chance of the elderly person being considered as temporarily unfit to drive decreased by 54.96% (95% CI; 28.47% - 92.69%I; p<0.0001). When increasing a unit in the MMSE score, there was an increase in gait speed (GS) of 0.0091 (95% CI: 0.0005 - 0.0174; p=0.0366).

Conclusion: The high MMSE score decreased the probability of the elderly participant being considered temporarily unfit to drive motor vehicles. There was a trend of higher GS with the increase in MMSE scores. As GS is an important indicator to be assessed in elderly drivers, this topic should be included in evaluations of traffic agencies, as well as cognitive screening, which is essential to assess a set of mental activities necessary for safe driving.

Resumo

Objetivo: Investigar a associação entre cognição, velocidade da marcha e resultado final da habilitação veicular de idosos candidatos à Carteira Nacional de Habilitação.

Métodos: Estudo quantitativo de corte transversal desenvolvido em 12 clínicas de trânsito de Curitiba/Paraná/Brasil. A amostra do tipo probabilística foi constituída por 421 idosos ($\geq$ 60 anos). Para a coleta de dados foram aplicados o Mini-Exame do Estado Mental (MEEM), teste de velocidade da marcha e realizadas consultas ao formulário Registro Nacional de Condutores Habilitados. A relação entre as variáveis foi identificada por meio do teste de regressão linear múltipla, método stepwise, utilizando-se o programa estatístico R versão 3.4.0.

Resultados: Observou-se que, ao aumentar o escore no MEEM em uma unidade a chance do idoso ser considerado inapto temporariamente para dirigir diminui em 54,96% (95%; IC 28,47% - 92,69%; p<0,0001), e ao aumentar uma unidade no escore do MEEM houve um aumento na velocidade da marcha (VM) de 0,0091 (95%; IC 0,0005 - 0,0174; p=0,0366).

Conclusão: O elevado escore no MEEM diminuiu a probabilidade do idoso ser considerado inapto temporariamente para dirigir veículos automotores e houve uma tendência de aumento da VM com o aumento dos escores do MEEM. A VM é um importante indicador a ser avaliado em idosos motoristas, logo, é um tópico a ser incluído nas avaliações das clínicas de trânsito, assim como o rastreamento cognitivo, fundamental para avaliar um conjunto de atividades mentais necessárias à direção veicular segura.

Resumen

Objetivo: Investigar la relación entre cognición, velocidad de la marcha y obtención del permiso de conducir en adultos mayores que tramitan la licencia de conducir.

Métodos: Estudio cuantitativo de corte transversal llevado a cabo en 12 centros médicos de evaluación de tránsito de Curitiba, estado de Paraná, Brasil. La muestra probabilística fue formada por 421 adultos mayores (≥ 60 años). Para la recolección de datos se aplicó el Mini Examen del Estado Mental (MEEM), la prueba de velocidad de la marcha y se realizaron consultas al formulario del Registro Nacional de Conductores Habilitados. La relación entre las variables fue identificada mediante la prueba de regresión lineal múltiple, método stepwise, con el programa de estadística R versión 3.4.0.

Resultados: Se observó que, al aumentar la puntuación del MEEM una unidad, la probabilidad de que el adulto mayor sea considerado no apto temporalmente para conducir se redujo un 54,96 % (95 %; IC 28,47 % - 92,69 %; p<0,0001), y al aumentar una unidad la puntuación del MEEM, hubo un aumento en la velocidad de la marcha (VM) de 0,0091 (95 %; IC 0,0005 - 0,0174; p=0,0366).

Conclusión: La puntuación del MEEM elevada redujo la probabilidad de que el adulto mayor sea considerado no apto temporalmente para conducir automóviles y hubo una tendencia de aumento de la VM con un aumento de la puntuación del MEEM. La VM es un indicador importante que debe ser evaluado en adultos mayores conductores. Por lo tanto, es un tema que deberá ser incluido en las evaluaciones de los centros médicos de evaluación de tránsito, así como también el rastreo cognitivo, fundamental para analizar un conjunto de actividades mentales necesarias para una conducción vehicular segura.

Introduction

As an indicator of mobility, driving a vehicle provides a number of social and health benefits to the elderly.[1] However, aging-related functional limitations result in a progressive and gradual loss of physical and mental abilities that interfere significantly with the ability to perform tasks such as driving motor vehicles.[2] This lack of skills raises concerns among elderly drivers and their families, and should be an object of concern for traffic institutions and government agencies too.

Maintaining the safe vehicle driving of the elderly is important, since it allows their access to different places, the performance of daily tasks and contributes to maintain their independence and autonomy. Elderly people should practice physical exercises regularly, undergo periodical ophthalmological evaluations, drive during daylight and use well-lit roads in order to drive safely.[3]

The cognitive demands related to driving a vehicle involve different domains such as memory, attention, executive function, visuospatial, psychomotor skills and coordination.[4] In fact, driving motor vehicles requires adequate cognitive processing for the appropriate decision making in traffic, which is admittedly a dynamic and complex environment.

Studies have shown the negative impact of aging on the driving performance of elderly people that can lead to the revocation of the driving license.[5] In France, a prospective study has shown that 54% of men and 63% of women have stopped driving or reduced the driving distance covered over six years, and dementia, Parkinson's disease and old age were restrictive factors for vehicle driving.[6] A population-based retrospective study identified the increasing risk of driving unsafely with advanced age and seniors were the only group of drivers with medical conditions affecting safety while driving.[7]

In Brazil, the National Traffic Department recorded 3.2 million drivers aged over 61 years in 2005 and in 2012, it increased to 3.6 million.[8] In the United States,[9] in 2017, there were 44 million drivers aged ≥ 65 years, representing an increase of 63% in relation to 1999. In Japan,[10] in 2018, there were 5.6 million driver's license holders aged ≥ 75 years, and that number is expected to reach 7.17 million in 2023.

In turn, gait speed is recognized as an indicator of the elderly's health and wellbeing.[11,12] Gait also evidences the impairment of physical and cognitive functions.[13] Regarding physical involvement, musculoskeletal changes in the elderly that result in decreased muscle quality and performance stand out.[14] Thus, Gait Speed (GS) assessment can be an important parameter to identify the physical condition of elderly drivers.

The underlying functional skills should be analyzed in the evaluation of vehicle driving, because

they are important for safe driving. For example, the cognition and motor performance with an approach including the assessment and intervention directed at the elderly.[15]

In view of the growing number of elderly drivers[15,16] and the factors determining traffic safety, there is concern with those who have cognitive changes and reduced gait speed.

Considering the scarcity of studies on the subject and cognitive screening and gait speed assessment as markers of mobility and the general health status in the elderly, the results may provide significant evidence of the elderly person's fitness to drive automotive vehicles.

To this end, the aim of the study was to investigate the association between cognition, gait speed and the final result of vehicle habilitation of elderly candidates for the National Driver's License.

Methods

Quantitative cross-sectional study conducted with elderly subjects (≥ 60 years) in 12 traffic agencies accredited to perform physical and mental aptitude testing for the driver's license, located in Curitiba (state of Paraná), Brazil.

The sample calculation was performed based on the number of elderly (N) on the last census, estimated by the Brazilian Institute of Geography and Statistics, which was of 198,089 elderly people in the city of Curitiba. A confidence index of 95% (CI = 95%), a significance level of 5%, an estimate of 50% proportion and a sampling error of 5% were considered, as described below:

$$n = \frac{Z^2 \; \hat{p} \; \hat{q} \; N}{d^2 \, (N \; 1) + Z^2 \; \hat{p} \; \hat{q}} \quad \text{where:}$$

N = population size;
Z = standard normal abscissa;
$\hat{p}$ = proportion estimate;
$\hat{q}$ = 1-$\hat{p}$;
d = sampling error.

The final value of the sample calculation was 384 elderly people. After adding 10% for losses and refusals, the final sample resulted in 421 elderly people.

The inclusion criteria were age ≥ 60 years, having scheduled and undergoing physical and mental fitness testing for driver's license in one of the traffic agencies. The exclusion criterion was having temporary physical limitations to undergo the tests (such as upper and/or lower limb fractures).

A simple random sampling technique from an updated list containing all agencies (54) was made available by the Traffic Department and used for the selection of traffic agencies. A manual draw was performed and a number between 1 and 54 was assigned to each agency. All numbers corresponding to the agencies were registered on small papers and mixed in an urn. The agencies were classified for data collection according to the order of draw lots.

The distribution and scheduling of elderly people for physical and mental fitness testing in traffic agencies is carried out by the Traffic Department of Paraná. Based on the equitable, random and impartial distribution of the elderly in the agencies, an equal number (35 elderly people per agency) was determined in order to guarantee the homogeneity of data and reduce bias in the study.

Fourteen traffic agencies located in different neighborhoods of Curitiba were contacted in a previously defined random order. Of these, 12 traffic agencies were included in the study and two were excluded because they did not have adequate physical space to perform the tests and the responsible person refused to take part in the research.

Data were collected from January 2015 to May 2016 and it took approximately 30 minutes per participant. Before starting data collection, the team of examiners (Phd, master and scientific initiation students) was trained by members of the research group. The aim of the training was to standardize the application of instruments and tests and define how to approach elderly people in the agencies. In addition, a pilot study was conducted (15 elderly participants) with the purpose of adapting the collection instruments. Since there was no need for changes, the 15 participants in the pilot study were included in the sample.

The Mini-Mental State Examination (MMSE) was used for cognitive screening and the Brazilian population-based version was adopted.[13] This cognitive screening instrument investigates the domains of orientation, immediate memory, attention and calculation, recall memory and language, and a score is attributed to each domain.[17] The MMSE score can vary from a minimum of 0 points, indicating a high degree of cognitive impairment, up to a maximum of 30 points, which corresponds to better cognitive ability.[17]

Gait speed was measured based on the proposed operationalization of physical frailty.[18] For the measurement of elderly people's gait speed, they were instructed to walk a total distance of 6 (six) meters as usual on a flat surface. The time (in seconds) to walk the central 4.6 meters of the path was timed using a digital manual stopwatch (Western). The distance of acceleration and deceleration was disregarded. The final value was the mean time taken to go through this path three times in a row.

The final result of the physical and mental fitness testing for the driver's license issued by the expert physician examiner of traffic was identified in the National Registry of Qualified Drivers form used by traffic agencies, which classifies the elderly as: Fit, Fit with restrictions, Temporarily unfit; or Unfit for driving. According to the current traffic legislation, the National Driver's License should be renewed every five years until the age of 65 years, then at every three years from the age of 65.[19]

Descriptive and inferential statistics were used for data analysis. The Multiple Linear Regression test, stepwise method, was used to identify the relationship between the variables with the R statistical software, version 3.4.0. The results of regression analysis were interpreted in terms of Odds Ratio (OR) and *p*-values<0.05 were considered significant.

The study project was approved by the Research Ethics Committee under number 833460. The ethical principles of voluntary and consented participation of all participants were observed, according to recommendations of Resolution number 466 of the National Health Council.[20]

Results

Of the 421 elderly participants (mean age 67.81±6.68 years), the mean GS value was 1.10±0.25 meters per second (m/s) with a minimum value of 0.36 m/s and maximum of 1.87 m/s. For cognition, the mean value in the MSEM was 27.13±2.53 points, minimum value of 18 points and maximum of 30 points. The results of physical and mental fitness tests showed a predominance of elderly people classified as Fit with restrictions (n=301; 71.5%), followed by Fit (n=92; 21.9%) and Temporarily unfit (n=28; 6.7%) to drive.

Table 1 shows the results of the final model for each grouping of results of the physical and mental fitness tests for vehicle habilitation and the covariate MMSE score.

When crossing the variables Fit+Fit with restrictions versus Temporarily unfit, the covariable MMSE score was significant with a negative relationship with the response. By interpreting this effect in terms of odds ratio, the increase in a unit of the MMSE score reduces the probability of being temporarily unfit to drive by 30.19% (95%; CI 14.34% - 48.61 %; p <0.0001).

For the aggregation of Fit versus Temporarily unfit, the MMSE score showed a significant and negative relationship with the response. In this case, when increasing the MMSE score in one unit, the chance that the elderly is considered temporarily unfit to drive decreases by 54.96% (95%; CI 28.47% - 92.69%; p <0.0001).

When grouping Fit with restrictions versus Temporarily unfit to drive, the MMSE score showed a negative significant relationship with the response. When increasing a unit of the MEEM score, the chance of being considered temporarily unfit decreased by 19.11% (95%; CI 6.99% - 33.98%; p=0.0023).

The results showed a significant association between the results of physical and mental fitness tests and the MMSE score. For the different aggregations of results of physical and mental fitness tests, the increase in the MMSE score significantly decreased the chances of elderly people being categorized as Temporarily unfit to drive. In the Fit versus

Temporarily unfit crossing, this effect was greater compared to the other aggregations.

Table 1. Results of the regression analysis for each grouping of results of the driver's license test of elderly participants

Covariable	Estimate	Standard error	Z statistics	p-value*
Fit + Fit with restrictions *versus* Temporarily unfit				
Intercept	4.4591	1.6400	2.719	0.0065
MMSE score	-0.2658	0.0660	-4.027	< 0.0001
Fit *versus* Temporarily unfit				
Intercept	10.7718	2.7504	3.916	< 0.0001
MMSE score	-0.4380	0.1022	-4.288	< 0.0001
Fit with restrictions *versus* Temporarily unfit				
Intercept	6.2889	1.6022	3.925	< 0.0001
MMSE score	-0.1748	0.0572	-3.057	0.0023

MMSE - Mini-Mental State Examination; *p-value related to the regression coefficient of variables for each variable in the predictive model (significant for p<0.05)

The results of the association between cognition and gait speed demonstrated that a unit increase in the MMSE score led to an increase in GS of 0.0091 (95%; CI 0.0005 - 0.0174; p=0.0366). There is a trend of a significant increase in GS with the increase in MMSE scores.

Discussion

The main finding of the present study was a significant association between the results of physical and mental fitness tests and the MMSE score. This indicates that the increase in the MMSE score decreased the chances of the elderly person being temporarily unfit to drive. Furthermore, there was an association between cognition and gait speed in elderly people.

The mean value of GS of elderly participants was 1.10 ± 0.25 m/s. A similar result was found in a study[21] of 6,391 elderly Japanese drivers, in which a mean GS value of 1.2 ± 0.2 m/s was observed. Gait speed values above 1.0 m/s indicate healthy aging and high life expectancy.[22] This indication is supported by the fact that walking requires energy, adequate movement control and the integration between cardiorespiratory, nervous and musculoskeletal systems.[22]

As for mean values in the MMSE (27.13±2.53 points), other studies showed convergent values. In elderly drivers in the city of São Paulo, this mean was 27.3 points[2], while in Japanese drivers (n=6,391) it was 26.3 poimts.[22]

The findings of the present study showed an association between cognition and results of the physical and mental aptitude tests for vehicle habilitation. Cognitive impairment was an important indicator of temporary inability to drive in elderly participants, since the higher the MMSE score the lower the chance of being temporarily unfit to drive.

Cognition has been recognized as one of the fundamental functions for the ability to drive motor vehicles. Driving a vehicle requires processing information and images that demand highly from different cognitive domains.[4] This is a complex task and the cognitive function decline affects the ability to operate a motor vehicle safely.[23] Aging it is the main risk factor for cognitive changes, which, in turn, affect safe driving.[24]

Continuous assessment to estimate cognition in elderly drivers is essential. Preventing them from driving is not a good strategy, as the suspension of this activity negatively affects the cognition of elderly people. An investigation with data from the Health and Retirement Study (longitudinal type) showed that elderly non-drivers at baseline had lower cognitive scores compared to active drivers. For those who stopped driving, cognitive decline was more accelerated compared to active drivers.[25]

There is no gold standard for determining elderly drivers' fitness to drive, nor a consensus regarding the assessment of elderly drivers with cognitive impairment. The MMSE is considered a rapid test limited to screening cognitive impairment in the elderly, but it still lacks standardization and evidence of validity.[26] Nonetheless, it has been used as a tool for assessing elderly drivers' cognition.[4,21] The validation of instruments and the establishment of cutoff points for cognition are key in the context of assessment for vehicle driving in elderly people.

The MMSE score has been associated with the ability to drive vehicles. An MMSE score ≤ 24/30 represents a 70% chance of error in the vehicle driving test on the road and a 19/30 score increases this rate to 95%.[25]

The study showed a significant association between cognition and the results of physical and mental fitness tests for vehicle habilitation in the elderly. Therefore, traffic departments and profes-

sional evaluators should pay special attention to the adequacy of traffic agencies for an assessment of cognitive follow-up in elderly drivers of motor vehicles. One of the starting points is the adaptation of current policies and legislation by offering support to traffic agencies in the detection of severe cognitive changes, because they prevent safe driving.[27]

The association between GS and cognition showed an increase in GS with the increase in the MMSE score. Results of studies conducted in other contexts also found an association between GS and MMSE scores. In a study conducted in Curitiba, was found a significant and positive association between the cognitive score and GS.[28] A cross-sectional study conducted with elderly people (≥ 65 years) recruited in care centers in the cities of Úbeda and Jaén/Spain indicated that GS is a predictor of the MMSE score.[29]

The decrease of GS performance throughout the aging process[30] is associated with adverse health events and has been adopted as a parameter of cognitive decline. Cognition and GS suffer declines with normal and pathological aging, and cognitive difficulties and gait abnormalities increase with age.[31] Slow gait speed is strongly associated with adverse health outcomes, including cognitive impairment.[32,33]

Much research has devoted efforts to identify the association between slow GS and cognitive changes. A prospective cohort study followed elderly people without dementia at baseline for nine years. Slow GS was associated with a higher risk of dementia (OR: 1.59; 95% CI 1.39-1.81, p<0.001) and walking was slower in the seven years before the clinical onset of dementia.[34] These findings corroborate the study [35] that reviewed prospective studies and identified GS as an additional marker to predict cognitive decline, as well as the study[36] in which the conclusion was an association between GS and cognitive performance in the elderly.

The Mayo Clinic Study of Aging followed elderly people in the community in Minnesota/USA for four years and found that cognitive scores and GS decreased over time. Since slow GS precedes cognitive decline, it can be useful as a reliable, easily measurable and non-invasive risk factor for cog-

nitive decline.[37] Likewise, the Health, Aging and Body Composition Study followed older adults in the community in Pittsburgh and Memphis/USA for nine years and identified a decrease in GS as a precursor to the decline in cognitive functioning in elderly people.[38]

The association between GS and cognitive decline is documented in the scientific literature. Longitudinal studies point to slow GS as a factor preceding cognitive decline. This finding is important for targeting preventive actions for this population, specifically for elderly drivers, using GS as an indicator. The combination of slow GS and cognitive complaints is a powerful tool for estimating those at high risk for developing dementia and targeting interventions such as cognitive training and physical activity in order to mitigate or prevent gait changes and cognitive decline with age.[31]

In the present study, the results of vehicle habilitation of the elderly and GS were significantly associated with cognitive scores (MMSE) and the scientific literature has indicated GS as a predictor of cognitive decline. Thus, GS becomes an important indicator to be assessed in elderly drivers.

The limitations of the study include the use of data collection instruments with self-report questions that can generate information bias, as well as the cross-sectional design that makes it impossible to determine the temporality of the analyzed factors and establish cause and effect relationships of the investigated variables.

The main finding of the present study was a significant association between the results on physical and mental fitness tests and the MMSE score. For the different aggregations of results of physical and mental fitness tests, the increase in the MMSE score decreased the chances of the elderly being considered as Temporarily unfit to drive. There was also an association between cognition and gait speed in elderly participants.

Conclusion

The results of physical and mental fitness tests for vehicle habilitation indicate a prevalence of Fit with

restrictions elderly and were significantly associated with cognition. The high MMSE score decreased the likelihood of the elderly person being considered as Temporarily unfit to drive. There is a significant association between gait speed and cognition, indicating a trend of higher gait speed in elderly people with a high MMSE score. The associations identified and the evidence in the scientific literature on GS as a predictor of cognitive decline demonstrate that GS is an important indicator of elderly people's conditions to drive. Thus, this variable should be included in assessments of traffic agencies especially targeted at the elderly population. The merit of cognitive impairment screening of elderly drivers is highlighted, as this strategy allows selecting those with cognitive impairment and assessing a set of mental activities necessary for safe driving. Proposing interventions to maintain and improve cognition and physical exercise programs to elderly drivers is relevant. In addition, is emphasized the importance of interdisciplinary actions involving health professionals, traffic departments and family members of elderly people focused on the theme of aging and the traffic system.

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Collaborations

Binotto MA, Lenardt MH, Carneiro NHK, Cechinel C and Lourenço TM contributed to the design of the study, analysis and interpretation of data, writing of the article, relevant critical review of the intellectual content and final approval of the version to be published. Bento PC, Rodríguez-Martínez MC contributed to the writing of the article, relevant critical review of the intellectual content and final approval of the version to be published.

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