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Title page

Driving Ability in Patients with Dizziness: a Systematic Review.

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Abstract

Introduction- Dizziness is considered one of the most common symptoms in general medical practice. Patients can suffer from a wide range of symptoms that are highly relevant while driving and may affect driving ability. In most countries driving restrictions have been suggested for patients with dizziness or a vestibular disorder. However, these restrictions are not always evidence-based and differ significantly between European countries.

Objective- The aim of this systematic review was to identify and evaluate studies dealing with driving performance of dizzy patients or patients with a vestibular disorder.

Methods- A systematic review was performed according to the Preferred Reporting Items for Systematic Reviews and Meta-analysis guidelines. (1) Data sources: PubMed and the reference list of the included articles. (2) Study selection: articles about driving ability and reported driving difficulties in patients with dizziness, or a diagnosed vestibular disorder, were included. (3) Data extraction was performed by two independent authors using predefined data fields: patient's characteristics, diagnostic criteria, sample size, type of evaluation of driving ability and outcome of the study. The protocol (ID 178086) is available online at PROSPERO.

Results- Eight out of 705 articles matched the inclusion criteria but varied widely regarding the study population, study design and outcome measures. The majority of studies reported a negative impact of dizziness and/or vestibular disorders on self-reported driving ability and car accidents. Yet several studies could not identify any impairment of driving ability.

Conclusions Driving ability was negatively affected by dizziness or a vestibular disorder in the majority of included studies with low risk of bias. This systematic review revealed a significant heterogeneity in reporting driving performance and contradictory results. We were therefore unable to identify a causal relationship between dizziness and driving ability. There is a need for prospective studies in populations with different vestibular disorders using subjective and objective outcome measures that have been validated to evaluate driving performance.

Introduction

Driving supports the patient's autonomy and stimulates social and professional participation in our society. Imposing driving restrictions should be well considered as it will affect personal autonomy for the benefit of public road safety. Driving is a complex task, combining perceptual, motoric and executive functions. A conceptual model, in which the goals and motives of the driver play an essential role, can be used to describe the driver's task. Decisions during driving can be subdivided in three hierarchical categories: operational (control), tactical (specific situations, maneuvering), strategic (planning) as described by Michon et al. 1985. The first, operational level, includes basic actions for instance steering, braking and changing gears. The second, tactical level is influenced by the specific traffic situations and weather or road conditions, decisions in this level include the distance with the car in front and driving speed. The third (and highest) level includes decisions which are made before driving the car for example planning the trip and route, assessing the costs and the risks.[1] The physical and mental health of the driver determines at which level these tasks can be performed. Several medical conditions such as dizziness can influence the driving performance.

Dizziness is one of the most frequent symptoms in daily medical practice. Yearly, dizziness affects up to 20% of adults.[2] Dizziness can be caused by various medical conditions, can be triggered or it can arise spontaneously.[3] Vestibular disorders can cause a broad range of symptoms such as dizziness, vertigo, lightheadedness and instability. Several of these symptoms can occur while driving and thus compromise -at least temporarily- the driving ability and may put the patient and their surroundings at risk.[4,5] There is a lack of uniformity regarding driving regulations of the dizzy patient and a lack of consensus for clinicians on how to evaluate driving ability in dizzy patients.[4,6] This can be attributed to discordant literature. For instance, a recent communication of DIZZYNET (a European network initiative for vertigo and balance research) with data gathered by an insurance company shows there is no increased risk of traffic accidents in people with acute unilateral vestibulopathy or MD. [7]

Traffic safety is prioritized by most governments and includes guidelines and regulations concerning alcohol intoxication, the use of mobile phones and driving restrictions for several conditions such as epileptic seizures, etc. [8-10] Patients with chronic vestibular disorders, such as uncompensated unilateral or bilateral vestibulopathy, encounter postural imbalance, gait unsteadiness and movement-induced oscillopsia. The latter is highly relevant while driving because it can influence the dynamic visual acuity. Nonetheless no consensus is found in the national driving regulations. An appropriate example of the differences in the national regulations is illustrated by the rules related to vestibular disorders. In Finland, Sweden and Denmark no driving restrictions are present for patients with vestibular disorders, whereas in Germany very strict regulations are present. For example, patients with bilateral vestibulopathy are in general considered as unfit to drive and patients with attacks of vertigo, such as in vestibular migraine or menières disease (MD) should have 2-3 years of attack free intervals before they restart driving. [4]

The objective of this systematic review is to identify and critically evaluate studies related to driving performance in dizzy patients or patients with a vestibular disorder and to help defining objective measures and methods towards better regulation of driving restriction for this condition.

Methods

This systematic review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines (PRISMA 2009).[11]

Information resources

The search query (Appendix 1) was conducted in the PubMed and Cochrane database on February 1st 2020. In addition, the reference list of the included studies was manually screened. The protocol (ID 178086) is available online at PROSPERO (www.crd.york.ac.uk/prospero).

Eligibility criteria

Participants: Studies involving patients with dizziness or patients having a diagnosis of a vestibular disorder were included. Adult patients aged 18 years or older were included because this is the age at which the driver's license can be achieved in Belgium

Intervention: Studies assessing on-road driving performance or driving ability using at least one question or questionnaire were included. Studies assessing driving ability using driving simulation were also accepted.

Comparator: No restrictions were imposed.

Outcome: Studies reporting on driving difficulties, driving behavior, measurements during driving simulation, safety surrogate indicators and car accidents or a surrogate of car accidents were included.

Study design: Case reports, opinion articles and narrative reviews were excluded because objective information is preferred for analysis.

Publication date: No restrictions were imposed regarding the publication date.

Language: Articles written in English, French or Dutch.

Search strategy

The search strategy is indicated in appendix 1. The search was conducted independently by two researchers (M.H.U. and V.V.R.).

Data extraction

Extraction of data was performed by two independent authors (MHU and VVR) using predefined data fields: (1) characteristics of patients, diagnostic criteria (2) population sample size (3) type of evaluation of driving ability (4) conclusion of the study.

Risk of bias assessment

The articles were assessed taking into account the following risks of bias:

- Confounding: confounders are co-variables such as age and gender that may influence the dependent variable (experiencing dizziness) in relation to the independent variable (driving difficulties).
- Selection bias: when the study population is not truly representative for the entire target population, selection bias may occur. This type of bias is typical for a case control study, but it is less likely to occur in a cohort study.
- Recall bias: when participants recall systematically more or less difficulties with driving because of their dizziness, recall bias can arise. This is a subcategory of classification bias.
- Performance bias: this bias form arises when there are systematic differences between the group experiencing dizziness and the comparator group.
- Bias due to missing data: due to the exclusion of individuals with missing data or inclusion of data with missing information about driving difficulties, e.g. incomplete questionnaires, bias can occur.
- Detection bias: For instance, questionnaires are subject to detection bias because there is a risk of missing the outcome of interest. When this happens bias in measurement of outcomes occurs.
- Selection of the reported results: this bias occurs when specific subsets of data are selectively reported to support a conclusion.
- Response bias: when the outcome variable is obtained from a sample of the study population, for example in case of polls or questionnaire-based enquiries, response bias may occur. To enable a better interpretation of the results emanating from these studies, the risk of response bias is defined as low in case of the response rates (RR) was more than 80%.

Results

Study selection

The search strategy identified 705 hits in PubMed, no duplicates were present. After the selection procedure a total of 20 articles were identified for full-text screening. Eventually, 8 studies matched the inclusion criteria. No additional articles were found by searching the bibliographies of the included articles. The flowchart of the selection procedure and the reasons for exclusion are presented in Figure 1.

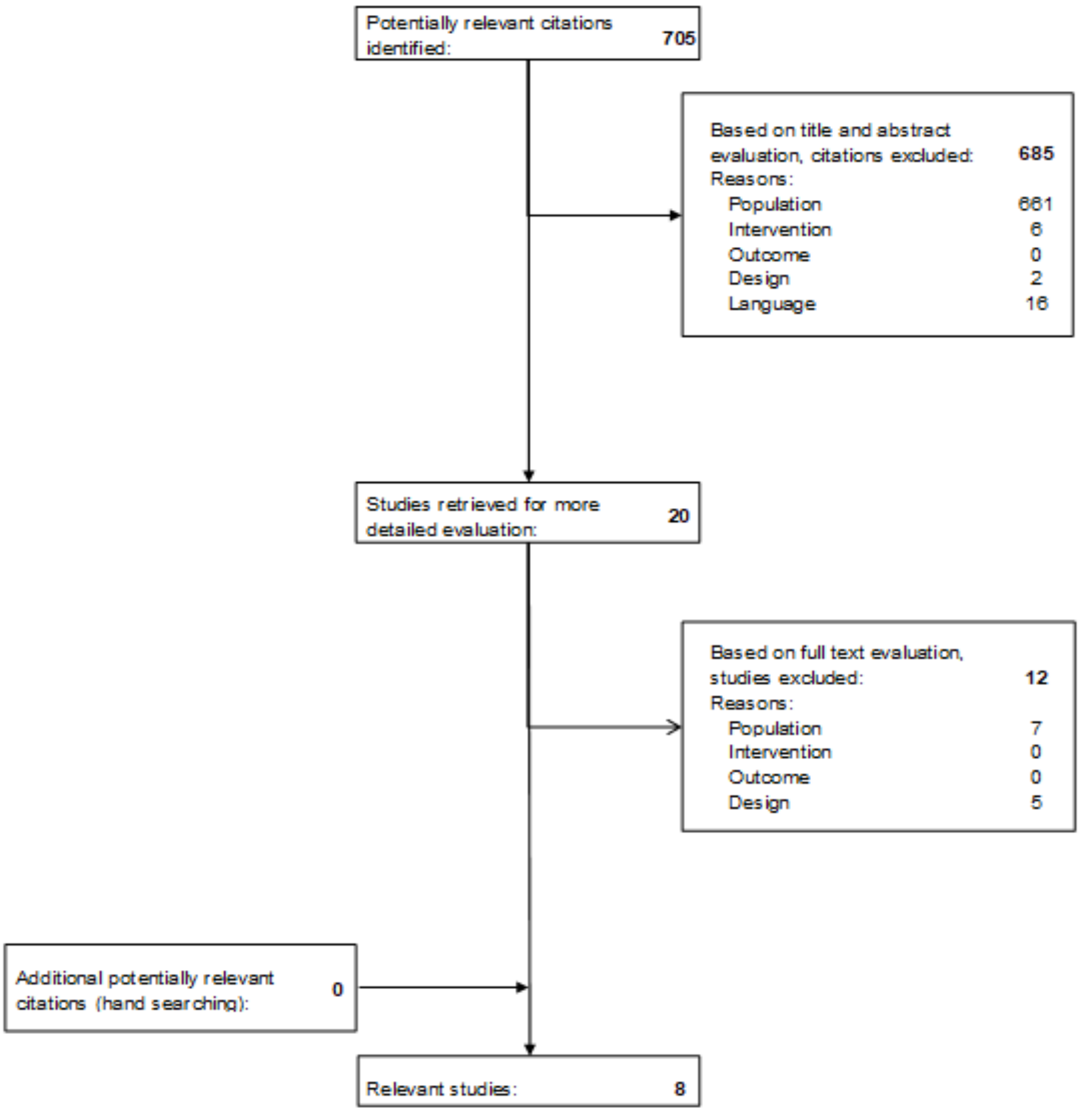

Figure 1: selection procedure

Information extraction

A comprehensive and detailed overview of the included studies is presented in Table 1. In total 8 papers were deemed eligible, reporting on a total of 37.065 participants. The respective study populations were heterogenous, not only in the number of patients [3-29 957] but also in the diagnostic criteria used. If patients were categorized in diagnostic subgroups, none of them reported validated diagnostic criteria for each of these categories. The study population was selected based on questionnaires in the two large population-based cohort studies[12,13] and in one study a modified Romberg test as surrogate for vestibular function was used.[14] The majority of the eligible studies used questionnaires about driving habits and motor vehicle accidents to assess driving ability. Additional outcome measurements included head-eye coordination and dynamic visual acuity during an on-road 20-minute driving test[15] and whiplash injuries as a surrogate marker for motor vehicle accidents.[16] None of the included studies used safety surrogate measures as an indicator for traffic safety.

Summary of included studies

Sindwani et al. (1999), assessed the impact of dizziness on driving ability in an outpatient ear-nose-throat clinic using a questionnaire. A total of 265 patients presenting with dizziness were included. The multiple-choice survey consisted of questions on demographic data, driving habits, dizziness history, the impact of dizziness on driving, compliance, and the perceived role of doctors in reporting patients who are unfit to drive. Twelve percent of the participants (31/258) reported a car accident injury caused by dizziness. In this survey, chronic and severe dizziness were identified to correlate with a higher risk for traffic accidents.[17]

Cohen et al. (2003), assessed the impact of vestibular disorders on driving ability using the Driving Habits Questionnaire (DBQ) and six additional questions about problems specific to people with vestibular disorders. Examples of specific problems were: pulling over to the roadside due to vertigo, staying inside the driving lane, and parking. A total of 118 patients with a vestibular disorder were included and compared to a control group of healthy subjects. The following vestibular disorders were inventoried: chronic vestibulopathy, benign paroxysmal positional vertigo (BPPV), MD and postoperative patients after acoustic neuroma resection or vestibular nerve section. Difficulties while driving were reported in specific and complex situations with less or complex visual feedback such as pulling into or out of parking spaces, changing lanes in traffic, staying in lane while driving, checking for traffic before pulling into an intersection, and driving around a ramped parking garage. MD patients and patients with chronic vestibulopathy were most affected by these situations.[18]

MacDougall et al. (2009) assessed the driving ability by analyzing measured point-of-regard (what the driver is looking at and attending to), gaze stability and head movement during a driving test. A total of three patients with bilateral vestibulopathy were compared to an age-matched control group. Head-eye coordination was measured using a custom-made video eye movement system that measured head, eye, and vehicle movement during a driving test. The point of regard, gaze stability and number and amplitude of head movements during a 20-minute drive in a civil area did not differ significantly from that of age-matched healthy controls.[15]

Ward et al. (2013) assessed the driving ability by analyzing data on driving behavior and motion discomfort compiled in a large cross-sectional study, the United States National Health Interview Survey (NHIS, 2008). The authors suggested a survey-based definition of bilateral vestibular hypofunction (BVH). For this survey-based diagnosis all of the following symptoms had to be present: blurred or fuzzy vision when moving their head, feeling off-balance or unsteady, drift to the side when trying to walk straight, having difficulty walking in the dark or walking on uneven ground or surfaces. The dizziness had to be identified as a significant impairment with a duration greater than one year and excluding neurologic or visual conditions. Dizziness or balance issues were experienced by 3.411 respondents (14,8%), excluding dizziness caused by alcohol intake. Twelve out of 3411 respondents matched the definition of BVH as described earlier. In total 44% of the 12 BVH patients reported limiting and changing driving habits due to the symptoms. Most of these participants experienced motion discomfort, particularly in tunnels, navigating stairs, escalators or moving walkways, or driving along as a passenger. [12]

Wei and Agrawal (2017) assessed driving ability using a question targeting driving difficulty (How much difficulty do you have driving during the daytime in familiar places?) in a large cross-sectional study (i.e. National Health and Nutrition Examination Survey; NHANES, 2001-2004). A total of 3.071 participants, aged 50 years or older, were selected for a clinical vestibular examination with the modified Romberg test (Table 1). Answers on the question were dichotomized: no difficulty vs. any difficulty. Of the participants 51,9% (1.592) did not pass the test and 279 (9.1%) answered positive on the Driving Difficulty Question. A multivariate statistical analysis demonstrated a two-fold increase of the odds for driving difficulties in the presence of vestibular dysfunction (OR 2.16-, 95% CI 1.57,2.98). The prevalence of driving difficulties was influenced by a series of confounders such as gender, age, ethnicity, education, presenting visual acuity, vestibular function and history of falls. A higher age and female gender were identified with higher risk to report driving difficulties.[14]

Wei and Agrawal (2018) assessed the driving ability by family-reported motor vehicle accidents in the past three months in a large population-based cross-sectional study (i.e. National Health Interview Survey; NHIS, 2016). A total of 30.145 participants completed the Adult Balance Supplement (response rate of 96,5%). Affirmative answers were reported on one of the three vestibular vertigo questions in 14.7% of participants. These questions included the presence of (1) rotational vertigo, (2) positional vertigo or (3) recurrent dizziness with nausea and either oscillopsia or imbalance. Motor vehicle accidents were defined as a binary outcome (no accident versus one or more accidents). An accident was defined as an injury for which medical support is sought and occurred when the participant is the driver of the motor vehicle. In the group with vestibular vertigo, 0.4% had an injury due to a car accident while driving in the past three months. In the control group without vestibular vertigo, this risk was 0.1% (OR 3.5; 95% CI 1.7-7.9).[13]

Pyykkö et al. (2019) evaluated driving ability using a non-validated questionnaire on driving avoidance, driving habits and (near-miss) car accidents. A total of 548 MD patients were included. In this study, MD patients were found to report fewer traffic accidents annually (0,9%) when compared to a control group of the general population (1,7%). In addition, the lifetime risk of car accidents was lower among subjects with MD (8,3%) compared to the control group (24-28%). Some absolutely avoid car driving (8,4%), while 81,4% have other strategies to ensure safe car driving for example driving avoidance during symptoms or in darkness or rain. [19]

Huppert et al. (2019) studied driving ability by using whiplash injuries as a surrogate marker for traffic accidents in a retrospective analysis including patients with a diagnosis of vestibular neuritis (VN, n=25.448) and MD (n= 4.509). Data were extracted from the Barmer health insurance system comparing vestibular neuritis patients with a control group. Because the incidence of whiplash injuries was unchanged before and after the diagnosis of VN and MD, the authors concluded there was no causal association between vestibular disease and higher risk of car accidents and they, therefore, found no reason to restrict these patients from driving. [16]

Risk of bias assessment

A methodological quality assessment was limited by a large variability in study designs, study population, inclusion criteria and interventions. For this reason, an alternative approach was used as described in the methods. In the following section the main risks of bias of the 8 selected papers were detailed and these were further summarized in table 2.

Article	Study design	Bias due to confounding	Selection bias	Recall bias	Performance bias	Bias due to missing data	Detection bias	Reporting bias	Response bias	Overall risk of bias
Sindwani R. et al., 1999	Case study	+	+	+	/	?	/	+	-	+
Cohen H.S. et al., 2003	Case-control study	-	+/-	+/-	-	?	-	-	?	+/-
McDougall HG. Et al., 2009	Case series	+/-	+	/	+/-	?	-	+	/	+/-
Ward. B.K. et al., 2013	Cross-sectional study	-	-	+	-	?	-	-	/	-
Wei E.X. and Agrawal Y., 2017	Cross-sectional study	+/-	-	+	-	?	-	-	/	-
Wei E.X. and Agrawal Y., 2018	Cross-sectional study	-	-	+/-	-	?	-	-	-	-
Pyykko I. et al., 2019	Case study	+	+/-	+	+	?	/	-	+	+
Huppert D. et al., 2019	Retrospective cohort study	+	+	/	-	-	+	-	/	+/-

Table 2. Risk of Bias assessment: +, high risk of bias; +/-, intermediate risk of bias; -, low risk of bias; ?, bias cannot be evaluated because lack of information; /, type of bias not applicable to study.

The following limitations were identified in the study of Sindwani et al. (1999). As such with respect to the study population, both an age distribution and a control group were missing. Further selection bias may have been occurred as the study population included only patients from an ear-nose-throat clinic. Hence for those subjects it is more likely that they are suffering from severe and chronic dizziness than the general patient population. Moreover, non-validated questionnaires were used which results in a high risk of recall bias. Additionally, as at least 1 of the 5 items of the applied questionnaires were not included in the result section, reporting bias was evaluated as high. On the contrary, the gender distribution was nearly equal, hence this was not likely to be a confounding factor. Further with a response rate of 97%, the risk of response bias was low. Finalluy, the risk of bias due to missing data was low as no missing data were reported.[17]

In the study of Cohen et al. (2003) an uneven gender distribution was considered with a female/male distribution of nearly 2:1. Further this unequal gender distribution was not taken into account in the analysis of the results and conclusions. This could lead to confounding bias. On the contrary no significant differences among the diagnostic and control group were present in respect to age (p=0,607) and gender (p=0,224), resulting in a low risk of performance bias. A validated questionnaire (i.e. DHQ) was used, hence there was an intermediate risk of recall bias. Bias due to missing data was unaddressed as no information was reported regarding incomplete questionnaires.[18]

The study of MacDougall et al. (2009) was more prone for selection bias due to the small sample size (n=3) considered in their study. Further a potential confounding factor was the small age range of the test and the age-matched control group (63-69y). Moreover ,performance bias may have been occurred as the control group was not matched to gender. In the results of their study a high risk of reporting bias was present as no measurements regarding point of regard and gaze stability were given in the result section.[15]

A low overall risk of bias was evaluated in three large cross-sectional studies: (1) Ward et al. (2013), (2) Wei E. and Agrawal Y. (2017), (3) Wei E. and Agrawal Y. (2018). Still due to the study design (cross-sectional) no causal relationships could be determined. Furthermore a potential confounder of the study of Ward et al. (2013) include the unequal gender distribution in which more female than male (89/11) participants are included.[12] Next, in the study of Wei E. and Agrawal Y (2017), a risk of detection bias was the estimation of vestibular function by the modified Romberg test which was considered as an aspecific physiologic test of peripheral vestibular function.[14] In the study of Wei E. and Agrawal Y. (2018) motor vehicle accidents could be missed by recall bias or when the accidents were not associated with an injury. In addition, no objective measurements of peripheral vestibular function were performed in their study. The risk of detection bias was low because the questions were completed by proxy respondents (i.e. a family member). Finally, there was a low risk of response bias based on a RR of 96.5%.[13]

In the study of Pyykkö et al. (2019) an unequal gender distribution in the study population (i.e. female/male patients = 411/137) results in a risk of bias. Further age has not been reported which was regarded as a potential confounder.

An intermediate risk of selection bias was scored because only patients of the Finnish MD association are included in this study which is a selected subgroup of patients. Moreover, recall bias could not be excluded in the study design as the study is based on questionnaires. Finally, there was a high risk of response bias based on a RR of 58.7%.[19]

A risk of bias in the study of Huppert et al. (2019) was evaluated based on the assumptions made in their study. As such patients diagnosed with MD and VN were selected based on the data of a statutory health insurer. Moreover, in this patient population whiplash injuries were accounted as surrogate for traffic accidents without considering the actual cause of the whiplash injury. This could lead to detection bias. At last potential confounding factors such as age and gender of the patients were not reported nor included in the analysis of this study.[16]

Discussion

This study aimed to systematically review available literature on driving performance in dizzy patients or patients with a vestibular disorder. According to most papers included in this study, it was concluded that dizziness has a negative impact on the driving performance. This was also confirmed by three large cross-sectional studies for which a low risk of bias was evaluated. Nonetheless also two of the included studies in this literature review did not observe any impact on driving performance. However, a higher risk of bias was observed in these studies. Moreover, in one of the studies a rather positive effect of a vestibular disorder on driving ability was present.[19] The latter could be attributed to the adjustment of the patients driving habits (e.g. limited car driving, only car driving during daytime) due to their vestibular symptoms. We were unable to demonstrate a causal relationship between dizziness and driving performance due to significant heterogeneity. For example, none of the studies used Barany society diagnostic criteria for including patients.

Remarkably, in all but one of the studies more female than male patients were included. E.g. the study of McDougall et al. only included 3 male patients.[15] Note that gender distribution is generally considered as a potential confounder and bias could arise when this is not taken into account in the analysis. Furthermore, in the study of Wei E. and Agrawal Y. (2017), female patients with vestibular vertigo indicated difficulties with driving more frequently compared to male patients (p 0,0013). Nonetheless when looking at the relationship between gender and the amount of car accidents Wei E. and Agrawal Y. (2018) concluded that no significant difference could be found between both genders (p 0,424). Hence, the included studies reveal that there is a difference related to gender, in how the patients evaluate their driving capability but not in the amount of car accidents.

According to Michon's model, most of the difficulties reported by the patient population are related to the first (operational) or second (tactical) level of the driving task. For example, due to the absence of the vestibulo-ocular-reflex in patients diagnosed with bilateral vestibulopathy, these patients experience difficulties to read and process stationary signs while driving or sitting in a driving car. Additionally, due to reduced spatial orientation difficulties are also experienced by these patients when changing traffic lanes or during parking. [20-22] Moreover conditions limiting the visual input of the patients such as driving at night or driving in heavy rain can impair the driving performance further at that moment.

Besides dizziness, other confounders may influence driving ability: anxiety, attention, age, gender and drugs (antidepressants,..). First of all, driving anxiety is experienced by many older adults, especially in female drivers.[23] A large proportion of female patients report high levels of driving anxiety and associated differences in driving patterns, e.g. drive less often, drive over shorter distances or use alternative transportation modes.[23,24]

Secondly attention capacity has been reported as an important factor for driving[25], a factor that has been demonstrated to be significantly impaired, especially in patients with bilateral vestibulopathy.[26-29] Attentional deficits may influence cognitive and motor dual tasks which are relevant while driving.[24,25,30-32]

Although conflicting data have been published on driving performance in stable outpatients, which are treated for depression[33], antidepressant medication is known to influence driving ability.[34] Two recent systematic reviews have studied the correlation between antidepressant drug use and driving.[35,36] Although the studies indicated a negative effect of antidepressants on driving performance, the epidemiological designs could not exclude the possibility that the underlying illness, generally a major depression, is the culprit. Additive effects with alcohol were most pronounced with sedating antidepressants.

At present efforts have been made to develop screening procedures to save part of the at-risk elderly driver population from stressful and costly on-road driving evaluations.[37] Similar efforts would be essential to evaluate individual driving ability in the patient population that report vestibular symptoms. Patients should be informed of the potential risk of driving when experiencing dizziness or having been diagnosed with a vestibular disorder.[5]

Even if dizziness can be considered as causing driving disability, it is unclear whether it can be identified as the main factor and to which extent it may influence driving ability in general. Consequently further research is suggested.

Future research directions

To make further conclusions about driving ability in patients experiencing dizziness or patients diagnosed with vestibular disorders, further studies are suggested, using more objective subgroups for example defined by the Barany society criteria.

These additional studies would allow to evaluate the relationship between driving ability and vestibular disorders further in a more comprehensive and objective way. As such based on additional research an evaluation could be made for each vestibular disorder to what extent the disorder influences the driving ability of the patient. These results could then help governments to enhance and update driving regulations.

For the additional studies it is suggested to use as secondary endpoints; (1) traffic safety surrogate markers and (2) self-reported driving ability evaluated by well-defined and validated questionnaires. The primary endpoint on the other hand could be the amount and severity of traffic accidents.

Conclusion

This study aimed to systematically review available literature on driving performance in dizzy patients or patients with a vestibular disorder. A negative impact of dizziness or a vestibular disorder on driving ability was revealed in most of the studies. This conclusion was also confirmed by three large cross-sectional studies for which a low risk of bias was observed. Nonetheless many studies included in this systematic review were highly heterogeneous in respect to the study population, the study design and the outcome measurements. Therefore, no causal relationship could be identified. Based on this systematic review, we identified a need for prospective studies in populations with different vestibular disorders (vertigo spells versus chronic dizziness). These studies should ideally use subjective and objective outcome measures that have been validated for their ability to evaluate driving performance.

Appendices

Appendix 1

The following search strategy was used: (("vertigo"[MeSH Terms] OR "vertigo"[All Fields]) OR ("vertigo"[MeSH Terms] OR "vertigo"[All Fields] OR "dizziness"[All Fields] OR "dizziness"[MeSH Terms]) OR vestibular[All Fields]) AND (("drive"[MeSH Terms] OR "drive"[All Fields]) OR ("automobile driving"[MeSH Terms] OR ("automobile"[All Fields] AND "driving"[All Fields]) OR "automobile driving"[All Fields] OR "driving"[All Fields]) OR (fitness[All Fields] AND ("drive"[MeSH Terms] OR "drive"[All Fields]))).

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