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THE EFFECTS OF FOOD AND DRINK INTAKE TO DRIVING PERFORMANCE: A SYSTEMATIC REVIEW

Summary. Human-related factors are considered to be the main cause of traffic incidents or accidents, causing 69.70% of the incidents. Several studies have been conducted to identify the relationship between drowsiness or fatigue and driving performance. Furthermore, a number of other studies not only discussed the symptoms causing drowsiness but also tried to investigate related factors that cause sleepiness or fatigue while driving. On the other hand, some discussed the quantity and quality of sleep as well as food and drink intake before and while driving. This systematic review, which is based on the PRISMA method, aims to map previous studies that investigated the effect of different food/drink consumption, either taken prior to driving or while driving, on the on-road driving characteristics of drivers. Furthermore, this article is expected to serve as a reference for further research that could potentially contribute to minimizing driving errors that lead to incident or accident. From 1871 articles screened, 7 studies related to food/drink intake and driving performance were reviewed. On the basis of the existing studies, no real evidence showing the presence of the association between food intake and the monotony of the road to decrease the driving performance has been found; therefore, further research is needed.

1. INTRODUCTION

The growth rate of traffic accidents in Indonesia is still high. During 2007-2016, in Indonesia, road accidents and traffic collisions were the most common type of accidents (65.6%). Among various types of traffic accidents, in 2014, a total number of 18,147 car accidents occurred. Although there is a decrease in the number of passenger car accidents by 8.8% per year, the number of accidents is still high, and thus resulting in large losses. There was an average increase of 35.8% casualties due to traffic accidents in the period 2007-2016 [1]. As per the data from the National Transportation Safety Committee, the main factors causing the accident were human factors (69.70%), compared to facilities factor (21.21%) and infrastructure (9.09%).

One of the major factors is driving errors due to drowsiness [2] and fatigue [3]. Several studies have been conducted to identify the relationship between drowsiness or fatigue and driving performance. In addition to fatigue and drowsiness, the driver's cognitive aspect, especially the level of driver's awareness of various road conditions, is also an interesting characteristic to consider. A number of other studies not only discussed the symptoms causing drowsiness but also tried to investigate related factors that cause sleepiness or fatigue while driving. On the other hand, some discussed the quantity and quality of sleep as well as food and drink intake before and while driving.

Some research studies have investigated the effect of food/drink consumption on the sleepiness and human driving performance. Orr et al. [4] studied the meal characteristics and their effect on

postprandial sleepiness. Another research by Karl, et al. [5] examined how the composition of protein and carbohydrate within meal influences mood, cognition, and sleep. Jacobson et al. [6] discussed the relationship of a meal consumption style, which causes obesity, with the performance of driving. However, studies indicating the relationship between various types of food/drink intake and driving performance are still scarce. This study aims to review some of the literature that reported the results of previous studies on driving performance and food/beverage intake. This literature review is expected to serve as a reference for further research that could potentially contribute to minimizing driving errors.

2. METHODS

This literature review is based on the Prefered Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) approach [7]. PRISMA method was applied because it provides a clear procedure and milestone for the review of specific area of study. First, the author defined the research question, the scope of the study, and inclusion/exclusion criteria, complying with the PRISMA statement. Afterward, a systematic screening of available literature was performed to select a set of eligible studies. The review steps were conducted by two independent groups (I.Z.S-G.B.P. & P.A.R.Y-H.R.S) and required a consensus before moving to the next step. Ultimately, the selected articles were reviewed and summarized.

The literature search was done using a combination of key words: (driver OR driving) AND (simulator OR vehicle OR road) AND (food OR drink OR diet OR meal OR intake OR consumption) AND (performance OR sleepiness OR response OR reaction OR alertness OR vigilance OR attention). Some inclusion and exclusion criteria for paper selection were also considered, as listed in Table 1. Related literature was collected from search results using three main reference search engines including ScienceDirect, Transportation Research Information Documentation (TRID), and SCOPUS (Table 2).

Table 1

Inclusion and exclusion criteria for paper selection

Study Element	**Inclusion Criteria**	**Exclusion Criteria**
Article type	Research paper published in international journal	Book chapter, reports, conference proceedings were excluded
Subjects	Healthy, non-professional driver, free from sleep disorders	-
Exposure (Independent variable)	Food and drink consumption were the main factors	-
Outcome measures (Dependent variable)	Driving performance: driving error, speed, number of incident/accident Sleepiness Driver reaction	-
Publication date	Studies published between 2008 and 2018	-
Publication language	Articles published in English	Articles published in other language were excluded

Table 2

Search characteristics from each database

No	Database	Limiters	Identified articles	Selected articles
1	ScienceDirect	Publication type: only journals, all sources, all sciences Publication year: 2008-2018	481	8
2	Transportation Research Information Documentation (TRID)	Publication type: only article and papers Language: English Publication year: 2008-2018	465	8
3	Scopus	Limit document type: article, article in press Limit language: English Publication year: 2008-2018	925	10

First of all, the title of the study became the basic parameter for filtering the literature in order to produce a fairly relevant list of papers. After the literature was filtered into smaller lists, a review of paper abstracts was conducted to collect the most focused studies on driving errors as well as food/drink intake. The final step was to review each paper to be analyzed so that the researcher can map the related studies that have been done so far in this area. The more detailed procedure of article search based on PRISMA flow is described in Fig. 1.

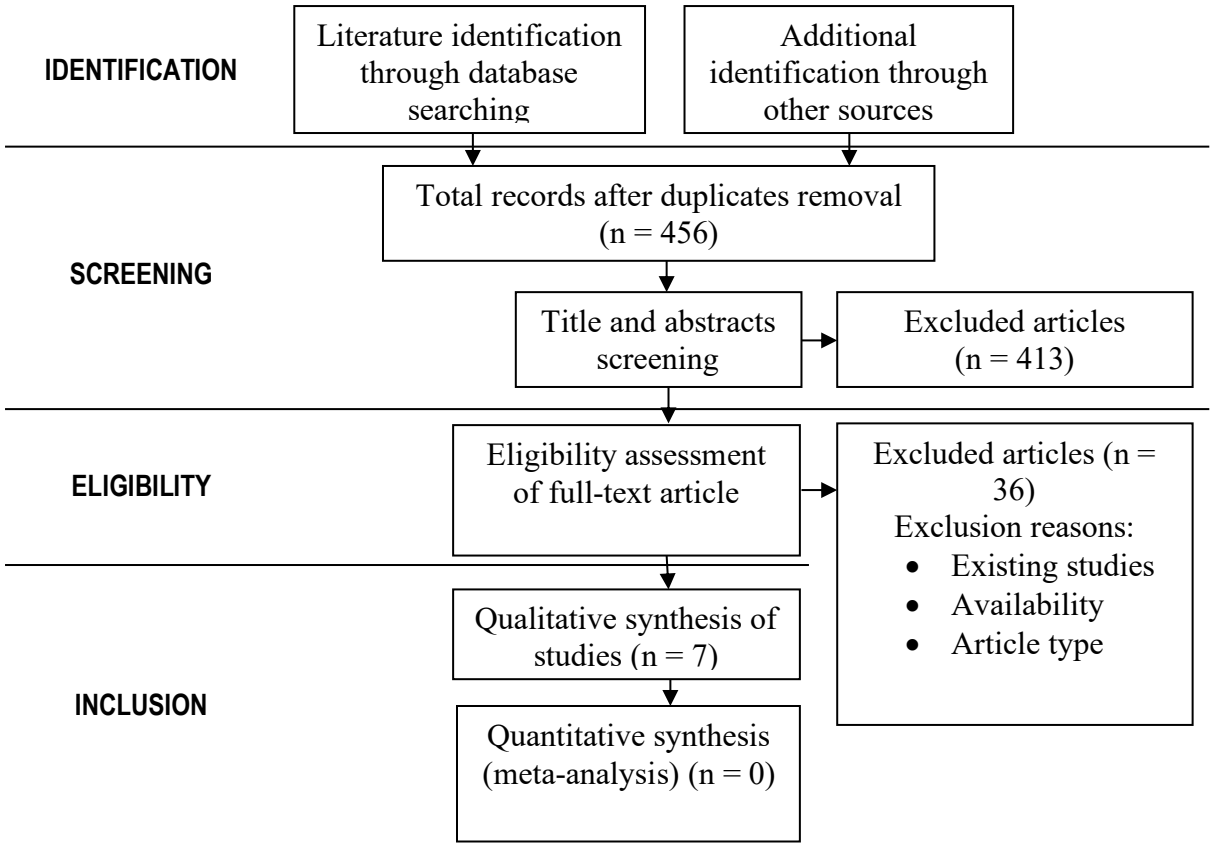

Fig. 1. Flow diagram of a systematic review (PRISMA)

3. RESULTS

Based on the procedure of the literature search for a systematic review, there were 7 studies reviewed in this paper. The specific title, study element, and the study findings are presented in Table 3.

4. DISCUSSION

Fatigue and sleepiness are a major contributing factor to transportation accidents [3], and food or drink intake is one of the potential causes of it. As regards to this fact, several studies have evaluated different possible types of intake that might be taken by the driver and their effect on driving behavior. According to the PRISMA-based systematic search in this review, there is only limited available evidence related to the effects of food and drink intake on driving performance. From the 7 studies reviewed in this paper, there is a heterogeneity of multiple study parameters and outcomes, which limits the generalizability of the findings. These study parameters are divided into driving-/driver-related measures, intake-related measures, and the road characteristics.

The road characteristics in the studies reviewed were mainly simulated long monotonous roads. Prolonged driving on monotonous roads is ideal for obtaining sleepiness and fatigue data on driving. Five out of the seven studies measured the sleepiness of the driver. A mixture of using objective and subjective measures has proven to be reliable in this area of research, especially when using Electroencephalograph (EEG) and Electrooculograph (EOG) [8, 9]. The subjective measures used included the well-proven Karolinska Sleepiness Scale [9, 10] or the Stanford Sleepiness Scale [11]. Other sleepiness parameters were eye blink, eye closure, eyes rolling upwards, and vacant staring.

Driving performance was measured in a number of different ways. Most studies measured the Standard Deviation of Lane Position (SDLP) and speed deviation [8, 10-14]. Other measures include braking reaction time [12] and the number of crashes or hits [8, 14]. It is arguable that driving measures that are more sensitive to change, such as lane and speed deviation, give better overall data to process, whereas measures like crashes, which are less likely to occur, are ineffective to measure driving performance related to food intake.

Intake-related measures are considered to be the most heterogeneous parameter and research related to them is scarce. Braag et al. [11] studied caffeine consumption and meal glycemic load. Ronen et al. [13] and Mets et al. [10] examined the effects of energy drinks. Watson et al. [8] limited the intake of drinking water, whereas Li et al (2016) studied the effects of alcohol. Only two studies evaluated the effects of food and drink intake on driving performance. The participants of the study conducted by Young et al. [14] ate simple snacks and consumed a bottle of water while driving. In contrast, Reyner et al. [9] suggested the consumption of light (305 calories) and heavy (922 calories) meal before driving in the driving simulator.

There are several studies that investigated the effects of alcohol and caffeine on driving performance, as reviewed in two separate articles [15-17]. However, currently, there is not much literature that discussed the influence of food or drink (besides alcohol and coffee) intake before/while driving on driving performance.

This literature review contributes to knowledge of the consequences that arise when driving on monotonous roads and its connection with food or drink consumed. This systematic review found, in general, no real evidence showing the presence of the association between food intake and the monotony of the road to affect driving performance. However, one study did find that heavy meals contribute to higher drowsiness levels and caffeinated drinks could increase driving performance and reduce the level of driver's sleepiness. There are several points that can be used as a reference for further research on driving behavior. Setting a straight and long path with a low-level stimulant proved to contribute to driver fatigue. There has been no real evidence showing the presence of the association of food intake and the monotony of the road to decrease the driving performance; hence, we recommend further study on this subject. Furthermore, there is still no study that compares different type of specific ingredients consumed by the driver.

Table 3

Mapping of research related to driving behavior and food/drink consumption

Author (Year)/ Title	Participant	Parameters			Findings
		Driving-/Driver-related measures	Intake-related measures	Road Characteristics	
Braag et al. (2017) *Effect of meal glycemic load and caffeine consumption on prolonged monotonous driving performance*	M: 7, F: 3 51±7 years old 97.4±19,9kg BMI 31.3±5.1 kg.m^{-2}	• Vigilance: Visual Analogue Scale • Sleepiness: Stanford Sleepiness Scale • Driving error: Standard Deviation of Lane Position / SDLP , Average Lane Position / AVLP, Lane Crossing / LC • Driving speed: Average Speed / AVSP, Standard Deviation of Speed / SDSP	• Caffeine (blood sample) • Glycemic load / GL (Blood Glucose Level)	Straight and long way (monotonic), 90 minutes driving (SCANeR Studio simulation engine v1.2r109)	• Significant decrease in SDLP (0.36 ± 0.20 m vs. 0.41 ± 0.19 m, p = 0.004) and LC (34.4 ± 31.4 vs. 56.7 ± 31.5, p = 0.018) on low GL conditions • There is no difference in the effect of glycemic consumption on driving performance
Li et al. (2016) *A simulation study of the effects of alcohol on driving performance in a Chinese population*	M: 34, F: 18 21-61y.o. (avg 38.2 y.o.) Min. 1-year driver's license	Driving behavior (*braking reaction time/BRT, standard deviation of lateral pos./SD-LANE, standard deviation of speed (SD-SPEED)*	• Alcohol (*Breath alcohol concentration/ BrAC*	Free driving, urban area, 4 hours (XP-300 Driving Simulator)	Driving performance (BRT and SDLANE) → is highly correlated with the level of alcohol consumption 1 unit increase Brac → BRT decrease (0.3%) and SDLANE (0.2%)

Watson et al. (2015) *Mild hypo-hydration increases the frequency of driver errors during a prolonged, monotonous driving task*	M: 11 22±4 years old Height 1.75±0.06m Body mass 77.4±10.0kg	• Vigilance: Visual Analogue Scale • Sleepiness: excessive blinking, eye closure, eyes rolling upwards, vacant staring ahead, EEG, EOG • Driving error: Lane drifting, late breaking, car wheel touching lane line, car hits a barrier or another car • Driving speed : Average Speed/AVSP, Standard Deviation of speed/SDSP	Hydration level (blood and urine sample) • Hydrated trial (200 mL of fluid every hour) • Fluid restricted trial (25 mL every hour)	Long and straight road, 2 hours driving (immobile car, with full size, interactive, computer-generated road projection)	• Mild dehydration leads to a significant increase in driving errors • It is unclear if the difference was caused due to the fluid restriction, different fluid intake during driving task, or combination of both factors.
Reyner et al. (2012) *Post-lunch sleepiness during prolonged, monotonous driving – Effects of meal size*	M: 12 19-25 years old (avg: 21years old) BMI 20-27 $kg.m^{-2}$ (avg: 23)	Sleepiness (Karolinska Sleepiness Scale, EEG, EOG)	Meal size • Heavy meal (922 cal.) • Light meal (305 cal.)	Straight and long (monotone), 120 minutes driving (immobile car, interactive, computer generated road projection)	*Heavy meal* → Significant increase in incident and EEG Power *Heavy meal* → higher subjective drowsiness trends

Ronen et al. (2014) *The combination of short rest and energy drink consumption as fatigue countermeasures during a prolonged drive of professional truck drivers*	M: 15 24-29 years old Minimum 5 years of truck driving experience	• Driving performance: lane position, longitudinal speed, steering wheel deviations • Subjective questionnaires: SOFI-20, NASA TLX • Physiological measures: ECG signals (R wave, R-R intervals, HRV)	• Energy drink • Energy drink + resting after 100 minutes of driving	Two-way monotonous and straight road, 40 minutes (STI-SIM fixed-based driving simulator, System Technology, Inc.)	Consumption of energy drink helped maintaining driving performance during the first part of drive
Mets et al. (2010) *Positive effects of an energy drink on driving performance during prolonged driving*	24 healthy volunteers	• Driving performance: standard deviation of lateral position (SDLP), standard deviation of speed • Sleepiness: Karolinska Sleepiness Scale (KSS)	Energy drink (caffeine, taurine, glucuronolactone, vitamin B, inositol)	Monotonous and prolonged road, 4 hours driving (STI-SIM driving simulator)	An energy drink significantly improves driving performance during prolonged driving
Young et al. (2008) *Crash dieting: The effects of eating and drinking on driving performance*	M: 16; F: 10 37.5 ± 12.9 years old	• Driving performance: speed, lane position, number of crashes, time-to-contact (TTC) • Mental workload (NASA Task Load Index)	Eating and drinking while driving (simple snack: a packet of sweets and a bottle of water)	Urban environment representative: two-way road (1.75 km), mixed curved and straight sections (11 curves); 553 seconds (average) of driving	There is no significant influence of eating and drinking while driving on driving performance

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