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Original Research

Karolinska Sleepiness Scale is not Associated with Obstructive Sleep Apnea Severity Indices in Male Taxi Drivers

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ABSTRACT

Objective: In the current study, we aimed to evaluate the diagnostic utility of the Karolinska Sleepiness Scale (KSS) for obstructive sleep apnea (OSA) in taxi drivers.

Methods: Forty male professional taxi drivers who participated in a driving simulator experiment in the sleep laboratory were included in the current study. All participants were asked to fill out the KSS before and after a 50-minute driving simulator task in the morning after overnight polysomnography (PSG) in the hospital. OSA was defined as an apnea-hypopnea-index (AHI) 15 events/hour on the PSG. Excessive daytime sleepiness (EDS) was defined as KSS score of at least 6.

Results: In all, only 3 cases fulfilled the criteria for EDS before the driving whereas 13 cases were sleepy after the task was completed (p <0.001). No significant association was found between KSS scores after the task and the PSG variables including total sleep time, time spent in delta sleep and REM sleep as well as OSA severity indices AHI and Oxygen Desaturation Index (ODI). The agreement between OSA and sleepiness on the KSS was calculated as 0.21 (p=0.07) indicating a very weak association. The KSS has a sensitivity of 24.1%, a specificity of 45.5%, a positive predictive value of 53.9%, a negative predictive value of 30.0%, an accuracy of 46.6% for the OSA diagnosis. The area under the curve was 0.57 (95% CI 0.39 – 0.74) for the AHI and 0.56 (95% CI 0.39 – 0.73) for the ODI, confirming a very poor performance of the KSS scores to predict AHI and ODI.

Conclusion: The KSS is not associated with the severity of the OSA indices in male taxi drivers. Objective measurements of EDS are warranted for a more precise evaluation of fitness to drive in professional drivers.

Keywords: Obstructive sleep apnea, daytime sleepiness, sleep testing

INTRODUCTION

Motor vehicle accidents (MVAs) remain one of the most prominent contributors to both fatalities and injuries not only worldwide, but also in Turkey [1, 2]. A recent review reported that 95% of the MVAs result from driver-related factors including high speed, alcohol consumption, substance use, fatigue, and daytime sleepiness [3].

Excessive sleepiness (EDS) is defined as an inability to maintain alertness and wakefulness during the major waking episodes of the day [4]. The occurrence of EDS has been estimated at around 30% in cardiac cohorts [5, 6] and up to 15% in general populations [7]. Turkish Adult Population Epidemiology of Sleep (TAPES) study estimated the ESS prevalence as 5.4% in

Turkey using a questionnaire-based method [8].

A medical disorder causing EDS is obstructive sleep apnea (OSA), which is a sleep breathing disorder characterized by intermittent episodes of upper airway obstruction (complete/partial) during sleep, resulting in intermittent hypoxia, variation in blood pressure sleep fragmentation, and increased activation in the sympathetic nervous system [6]. The OSA prevalence was reported up to 17% in the general population and it is more common in the elderly population [9]. Based on the TAPES study, the OSA prevalence is around 14% in the general population in Turkey [8]. OSA patients with daytime sleepiness have been associated with an increased risk for MVAs [1, 2, 10].

There are several self-rating questionnaires for EDS to use in the general population as well as sleep clinical cohorts. Karolinska Sleepiness Scale (KSS) is a one-dimensional Likert scale measuring the subjective sleepiness level at a particular time [11]. It has been demonstrated that falling asleep at the wheel during the simulator task is preceded by an enhanced score on the KSS [12]. KSS is used for both females and males and it is effective in measuring the changes in response to environmental factors [11]. There is yet no report regarding the association of sleepiness level measured with KSS and OSA severity in a sleep clinic cohort. The current study aims to examine the diagnostic utility of the KSS to predict OSA severity among male taxi drivers.

Main Points;

- The Karolinska Sleepiness Scale is not associated with the severity of obstructive sleep apnea indices in male taxi drivers.
- It can be used for measuring the changes in sleepiness levels of drivers during simulator tasks.
- Notwithstanding, these changes do not correlate with polysomnography variables including total sleep time, time in Delta and REM sleep as well obstructive sleep apnea severity indices apnea-hypopnea-index and oxygen desaturation index.
- The sensitivity, specificity, and accuracy values as well as the positive and negative predictive values suggest a poor performance of the Karolinska Sleepiness Scale to screen for obstructive sleep apnea (24.14%, 45.5%, 46.6%, 53.9%, and 30.0%, respectively).

MATERIALS AND METHODS

Participants

The current research includes 40 male taxi drivers who were recruited from the Sleep Laboratory at Koç University Hospital, Istanbul, for the driving simulator study. The participants were asked to fill out questionnaires and undergo an overnight hospital PSG. Participants were asked to refrain from consuming coffee and energy drinks, in addition to avoiding other stimulants before the overnight attendant hospital sleep testing. The inclusion criteria of the current study were having a driving license for more than three years and having been working as a taxi driver actively at least 6 or 7 days a week. Participants were deemed ineligible in case of having acute illness, and no longer held a valid driver's license. All subjects were invited to voluntarily participate in the present study, and they provided written informed consent. The study protocol has been approved by the Koç University Committee on Human Research (2020.292.IRB2.083; 19 June 2020). Each participant provided written informed consent.

Data Collection and Definition

Baseline demographic characteristics as well we comorbidities were documented. Body mass index (BMI) $\geq 30 kg/m^2$ was used to define obesity. Each participant filled out a questionnaire asking for information on sleep-related symptoms, and sleep habits, which were used in clinical routines. The KSS was administered before and after the driving simulator test to assess sleepiness.

Driving Simulator Test

Participants meeting inclusion criteria were scheduled for a driving session between 08:00 AM and 10:00 AM following the PSG. The lights in the cabin room were turned off and the door was closed. Each participant engaged in a fifty-minute simulated driving session on a two-way highway, with traffic density maintained at a low level. The XBUS PRO Driver Training Simulator (DTS), developed by ANGRUP Co. was used in the current study (Figure 1).

Karolinska Sleepiness Scale

KSS is a self-rated questionnaire assessing the subjective sleepiness level using a Likert scale ranging from 1 (Extremely alert) to 9 (Extremely sleepy, great effort to keep alert, fighting sleep) (Table 1). Although a score of 7 or more was suggested for EDS based on variations in electroencephalogram and electrooculogram recordings [11, 13], a recent study has reported that KSS exists in two versions, which are like each other with a high agreement and both versions can be used interchangeable [14]. Based on those results, a score of 6 was used as a threshold for sleepiness in the present study (Table 1).

Figure. 1. Driving simulator task.

Table 1. Items of the KSS and the categorization criteria used in the present study.

Version A (Original Scale)	**Version B**	**Categorization**
Item 1 Extremely alert	**Item 2** Very alert	No sleepiness
Item 3 Alert	**Item 4** Rather alert	
Item 5 Neither alert nor sleepy		No sleepiness
Item 7 Sleepy but no effort to keep awake	**Item 6** Some sign of sleepiness	Sleepiness
Item 9 Very sleepy, great effort to keep awake, fighting sleep	**Item 8** Sleepy, but some effort to keep awake	

Sleep Measurement

In the current study, a full-night PSG (NOX-A1 system; Nox Medical Inc., Reykjavik, Iceland) was conducted in the hospital and included EEG, EOG, chin and leg electromyograms, nasal airflow, thoracoabdominal and leg movements, body position, heart rate, and SpO^2. Sleep stages, arousals, apneas and hypopneas were scored based on The AASM 2012 criteria [15]. The oxygen desaturation index (ODI) was calculated as the number of significant desaturations (at least 3% from baseline). OSA was defined as an AHI ≥ 15 events/h of the total sleep time [16].

Statistical Analysis

Descriptive statistics were summarized as median with 25th and 75th percentile for the continuous variables, and as count with percentage for the categorical variables. Shapiro-Wilk Test was used for the normality assumptions. Regarding between-group differences, the Mann–Whitney U Rank Test was used for continuous variables, and χ^2 test or Fisher's Exact Test was used for the categorical variables. For the within-group comparisons, the Wilcoxon Nonparametric Test and the McNemar Nonparametric Test were used to analyze continuous and categorical variables, respectively. The agreement between OSA and KSS classification was established with hen's Kappa Coefficient. The association between PSG measurements and the total score of KSS was assessed using Pearson Correlation Coefficients. The diagnostic parameters of the KSS were calculated against the OSA. The receiver-operating characteristic (ROC) curve analysis was conducted to measure the association between the KSS results (Sleepy vs. non-sleepy) and the PSG parameters including AHI and ODI (continuous variables). The accepted significance level for all tests was 5% and statistical analyses were performed using IBM SPSS 28.0 for Windows SPSS Inc., Chicago, Illinois, USA.

RESULTS

The demographic and clinical characteristics of the study participants have been presented in Table 2. Proportion of the obesity was significantly different between the participants with OSA and those without OSA. Although the participants with OSA had a higher BMI, and SBP and had a larger waist circumference compared to the patients without OSA, those differences were not significant. As expected, the PSG parameters were significantly different between the two groups, per protocol.

Figure 2A illustrates that the majority of the study population reported a high level of alertness while only 3 participants rated themselves as sleepy on the KSS before driving performance at baseline. Following the simulator task performance, 11 cases were classified as sleepy and 2 cases as very sleepy according to KSS. The proportion of the participants with alertness decreased whereas the proportion of sleepy patients increased between two tests. McNemar's test result showed that the proportion of sleepiness was significantly different between the two tests (p=0.022).

As clearly illustrated in Figure 2B, in the whole study population, the total KSS score after driving performance was significantly higher than the total scores before the task, indicating the sleepiness level increased during driving (p= 0.021). In line with this result, there was a significant increase in the number of OSA patients after fifty minutes of driving (p= 0.022). However, no difference was found in the patient group with no OSA (p= 0.66). No significant between-group differences have been found regarding total KSS scores before and after the driving task (p= 0.37, p=0.99, respectively, data not shown).

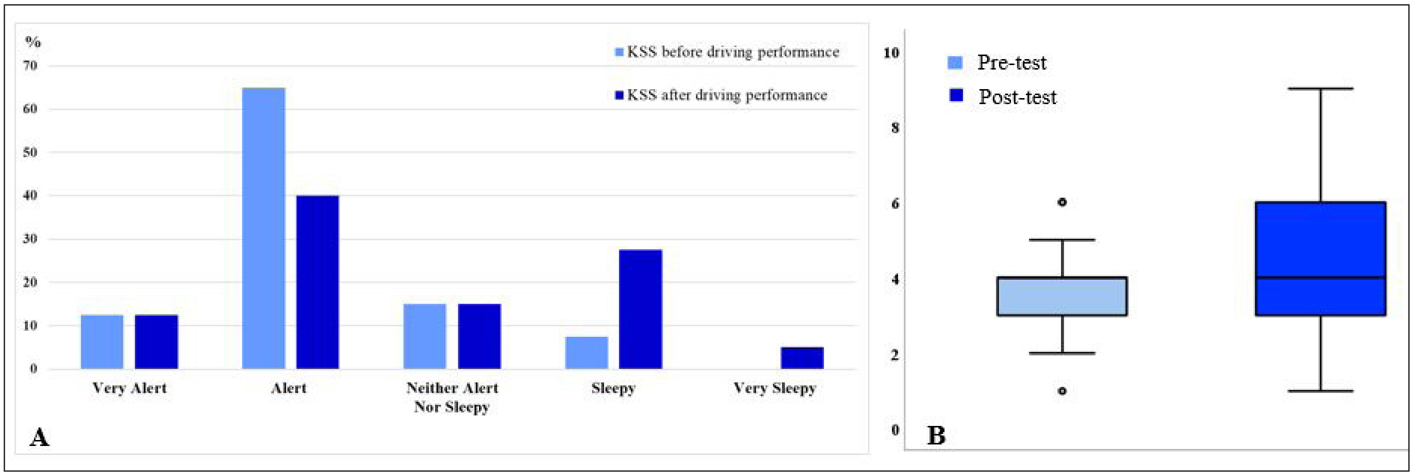

Figure 2. (A) Proportion of the participants' responses on the KSS before and after driving. task. **(B)** Distributions of the total KSS score.

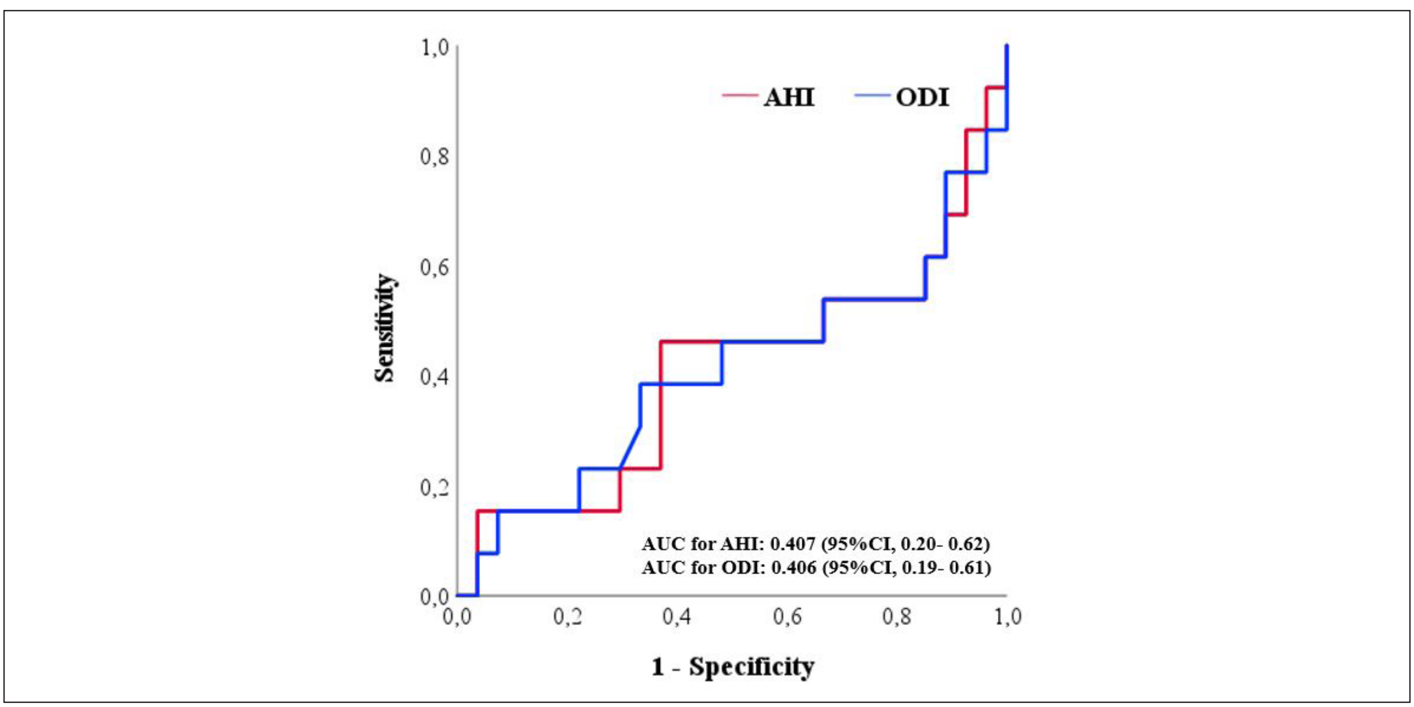

Figure 3. Receiver-operating characteristic curve of association between the KSS (with and without sleepiness) and the severity of OSA measured with AHI and ODI.

Table 2. Baseline characteristics of the study population.

	AHI ≥15 (N=29)	AHI <15 (N=11)	p
Demographics			
Age, yrs	45.1 (41.9-50.4)	45.1 (36.8-53.3)	0.72
BMI, kg/m^2	32.7 (28.9-34.3)	28.7 (23.8-32.1)	0.13
Marital Status, %	82.8	90.9	0.51
Obesity , %	67.9	28.6	0.05
Neck Circumference,cm	42.0 (41.0-44.0)	42.0 (40.0-45.0)	0.51
Waist Circumference, cm	109.5 (100.3-117.0)	102.5 (95.5-106.5)	0.36
Hip Circumference, cm	106.5 (103.0-114.8)	109.5 (100.8-112.3)	0.84
Smoking Status, %	43.8	72.7	0.36
Alcohol use, %	14.3	27.3	0.34
Family History for Snoring, %	69.0	72.7	0.88
Family History for OSA, %	10.7	0	0.50
Vital Signs			
SBP	123.0 (111.5-129.0)	119.0 (110.3-136.3)	0.54
DBP	80.0 (71.5-86.0)	84.0 (72.5-89.8)	0.43
Heart Rate	80.0 (74.0-96.0)	81.0 (69.0- 91.0)	0.56
SpO_2 (%)	98 (97-98)	98 (98-99)	0.08
PSG characteristics			
TST			
AHI	34.6 (18.4-47.9)	8.6 (6.4-11.0)	> 0.001
ODI	28.8(13.8-35.3)	5.4 (3.4-6.5)	> 0.001
Delta Sleep	68.0 (51.8- 91.0)	101.0 (78.5-126.0)	> 0.001
Rem Sleep	71.0 (48.0-83.5)	76.5 (64.0-106.0)	0.03
Comorbidities			
Allergy, %	14.3	9.1	0.56
Dyspnea, %	34.5	18.2	0.27
Asthma/COPD, %	7.1	0	0.51
Hypertension, %	17.9	9.1	0.44
Angina pectoris, %	6.9	9.1	0.63
AMI, %	0	9.1	0.27
PCI/CABG, %	6.9	0	0.52
Cardiac disease, %	6.9	0	0.52
Arrhythmia, %	6.9	9.1	0.63
Hyperlipidemia , %	10.3	9.1	0.70
Diabetes Mellitus, %	3.4	9.1	0.47
Neurological Disorder, %	3.4	9.1	0.47

Abbreviations; **AHI,** apnea-hypopnea index; **AMI,** acute myocardial infraction; **BMI,** body mass index; **CABG,** coronary artery bypass grafting; **ODI**, oxygen desaturation index, **PCI** percutaneous coronary intervention; **TST,** total sleep time; **SpO_2,** oxygen saturation

Table 3. PSG characteristics of the taxi drivers with sleepiness *vs* without sleepiness.

	Taxi Drivers with Sleepiness (N=13)	Taxi Drivers without Sleepiness (N=27)	p
TST	396.0 (339.5-422.5)	399.0 (358.0 – 424.0)	0.95
AHI	17.3 (8.2-38.7)	22.1 (15.7-44.5)	0.36
ODI	11.7 (5.3-31.2)	16.9 (10.1-30.3)	0.35
Delta Sleep	82.0 (44.5-104.5)	78.8 (57.5-103.3)	0.84
REM Sleep	72.0 (62.0-86.0)	71.5 (51.0-85.0)	0.73

Abbreviations: **AHI,** apnea hypopnea index; **ODI,** oxygen desaturation index; **REM,** repeat eye movements; **TST,** total sleep time.

Regarding the KSS classification, the patients with EDS had lower AHI, ODI, and longer total sleep time (TST) while having a shorter time in Delta sleep compared to the patients without sleepiness. However, none of those differences was significant. Furthermore, the time spent in REM sleep was also similar between the two groups (Table 3). No significant association was found between the total KSS scores, reported after the driving task, and the AHI, ODI, TST, time spent in Delta, and REM sleep (Pearson Correlation: 0.048, 0.054, -0.129, -0.079 and -0.044; p: 0.77, 0.74, 0.43, 0.63 and 0.79, respectively).

Based on the PSG, 7 (24.1%) patients with EDS were found to have AHI ≥15 events/h and 6 (54.4%) patients with sleepiness had AHI below 15 events/h. Corresponding numbers for the patients without EDS were 22 (75.9%) and 5 (45.5%), respectively. Kappa test statistic was calculated as -0.21 (p= 0.07), indicating a very weak agreement between OSA and KSS results. Diagnostic values of the KSS, including the sensitivity, specificity, accuracy, and positive and negative predictive values, were calculated as 24.14%, 45.5%, 46.6%, 53.9% and 30.0, respectively. Those values confirmed a weak diagnostic utility of the KSS for the OSA diagnosis.

The ROC curve of the association between the KSS (sleepy vs. non-sleepy) and the continuous AHI as well as ODI values have been demonstrated in Figure 3. The area under the curve was 0.57 (95% CI 0.39 – 0.74) for the AHI and 0.56 (95% CI 0.39 – 0.73) for the ODI, confirming a very poor performance of the KSS scores to predict the OSA severity.

DISCUSSION

The main finding of the current study is that the KSS is not associated with the severity of OSA indices in male taxi drivers. Although a fifty-minute driving simulator task enhanced the sleepiness levels of the taxi drivers, the PSG variables including TST, time spent in delta sleep and REM sleep, as well as AHI and ODI were not different between sleepy and non-sleepy drivers; and those variables were not associated with the drivers' sleepiness levels. Furthermore, the agreement between the OSA and the KSS was weak. In line with those results, the sensitivity, specificity, and accuracy values as well as the positive and negative predictive values provided evidence of poor performance of the KSS to screen OSA severity (24.14%, 45.5%, 46.6, 53.9%, and 30.0%, respectively).

This is the first study examining the association between KSS and OSA indices in a sleep clinic OSA population including taxi drivers. The data regarding the KSS in the clinical population is scarce. Previously, Wong et al. examined the effect of a forty-hour driving simulator task on the total KSS scores comparing OSA patients with controls [17]. According to their results, the patients with OSA had higher sleepiness levels than the patients without OSA at baseline. Nevertheless, the change in total KSS level was not significantly different between the OSA patients and the controls [17]. In the present study, there was no significant difference in the total KSS score between OSA groups at baseline. A possible argument could be that OSA patients included in the study conducted by Wong et al [17] had more severe OSA (Mean AHI= 49.8 events/hour) than the participants included in the present study (Mean AHI= 22.1 events/hour). Furthermore, we found a significant difference between the total KSS score at baseline and after the driving task within the OSA, while Wong et al [17] reported the change in KSS was not significantly different between the OSA groups. It could be explained as a regression to the mean since the OSA patients in the study of Wong et al rated their sleepiness as already high at baseline [17].

Although we found a significant increase in the KSS score after a fifty-minute drive in OSA patients, this result does not support the argument that the patients with OSA are more vulnerable to the EDS measured by the KSS than the controls. Therefore, it needs to be confirmed in a larger sample since no association has been found between the KSS and OSA severity indices.

Sleepiness can be defined as an inability to maintain wakefulness and alertness during the day [16]. It is associated with a loss of alertness and is considered to be a consequence of sleep fragmentation and adversely affects functioning, mood, cognition, productivity, and quality of life [18,19]. It affects a large part of the population and usually increases the risk of accidents. It has been suggested that 95% of the MVAs result from driver-related factors including fatigue and sleepiness. In recent years, a growing body of literature has paid particular attention to sleepiness since up to 20% of MVAs have been associated with sleepiness, especially on monotonous roads like [20, 21]. With the awareness of OSA as a risk factor for MVAs, several international strategies have been developed to identify the drivers with high-risk for sleepiness and OSA [3]. According to the updated report of the American Thoracic Society, an individual with moderate to severe daytime sleepiness can be classified as high-risk driver and should be initially evaluated for suspected OSA [22]. The legislation regarding the driving license and OSA was updated not only in Europe [23] but also in Turkey [3]. A full-night Polysomnography (PSG), a gold standard for OSA diagnosis, was recommended regarding commercial driver-license applicants who have symptoms of witnessed apneas and/or daytime sleepiness, snoring and for those with BMI >25 kg/m^2 before getting a license [3]. Given the long waiting list in public hospitals and the limited number of sleep centers, a full-night PSG for OSA diagnosis is not feasible in Turkey. This raises a need for the development of an alternative screening tool to identify a patient with high risk as well as a patient who would unnecessarily undergo PSG when the gold standard is very expensive and not feasible. More specifically, it seems that cheap, feasible, and reachable alternatives are needed and one such is the KSS.

As aforementioned, the KSS is a one-dimensional Likert scale to measure subjective levels of sleepiness. Several studies have shown that there is a high positive intra-individual correlation between KSS scores and alpha-theta activity in the electroencephalogram (EEG) as well as behavioral variables. Moreover, it was demonstrated that falling asleep at the wheel during the simulator task was preceded by an enhanced score on the KSS. Previously, the KSS has been found a reliable tool to measure subjective levels of sleepiness in different types of studies including shift work [24, 25] jet lag [26], attention and performance [12, 27, 28] and driving abilities [29-31]. The difference between our results and those studies might be due to the type of study population. The present study includes participants from the sleep clinic cohort rather than the participants in the experimental settings. Further research is needed to evaluate the utility of the KSS for the assessment of sleepiness in the clinical population.

Limitations

There are several limitations of the present study. First, the current sample consists of male taxi drivers who work 24 hours of shift and 6 or 7 days a week. The sleep pattern for other shifts might vary. Therefore, the generalizability of the findings to non-professional drivers would be limited. Second, assessing sleepiness using a self-rated questionnaire is open to bias since it might be influenced the perceived well-being state of the subject. Moreover, the taxi drivers in the present study might likely underestimate the severity of the sleepiness level for legal issues. Third, no objective measurement of sleepiness such as maintenance of wakefulness test or we did not measure physiological response to sleepiness using EEG recordings. These aspects need to be considered in future studies.

CONCLUSIONS

The present Karolinska Sleepiness Scale seems to be a weak screening tool to identify an individual with a high risk of obstructive sleep apnea. Objective measurements are warranted for a more precise evaluation of excessive daytime sleepiness in professional drivers to predict the high risk of obstructive sleep apnea.

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Author Contributions: Conception: YC - Design: YC -Materials: YC - Data Collection and/or Processing YC - Analysis and/or Interpretation: YC - Literature: YC- Review: YC Writing: YC.

Ethical Approval: Koç University Committee on Human Research approved the study protocol (2020. 292.IRB2.083; 19 June 2020)

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