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Stress Level among Indonesian Train Drivers – A Study Utilizing Salivary α-Amylase and Subjective Method

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Abstract: ***This research was motivated by the fact that train drivers in Indonesia seem to face stressful work conditions. These are associated with a number of factors, including tight train schedules, fairly substandard train operating conditions, the needs to continuously watch railway tracks for potential causes of derailments, poor level-crossing conditions, as well as activities done by the locals along the railway tracks. This study aimed at evaluating the levels of workload typically experienced by the train drivers. Salivary α-amylase (SAA) and Subjective Workload Assessment Technique (SWAT) were employed for this purpose. A total of 36 train drivers participated in this study, and were recruited from one of the largest train operational region in Indonesia. Levels of SAA were determined prior to, during, and immediately following a train-driving task, while SWAT was administered immediately following a driving task. Results of this study indicated SAA levels that were much greater than 60kU/l for the more than 70% of the drivers. This figure tended to decline (to roughly 56%) at the end of the task. Data on SWAT demonstrated relatively high workload; the time dimension, in particular, was the dominant factor associated with this workload. It was concluded in this study that workload among the train drivers was excessively high. A number of potential interventions are suggested here that can help reduce the level of workload among the train drivers.***

Keywords: Stress, Mental Workload, Salivary α-Amylase Activity, Subjective Workload Assessment Technique

1. Introduction

It is believed that excessive workload and stressful work conditions can lead to poor performance [1], and may eventually affect safety. This tenet is probably applicable in any work sectors, including railway industry. In fact, the literature has reported a number of major train accidents that are closely associated with high job demand and poor working environments.

For Indonesian railway operations, train drivers typically have to deal with unfavorable working conditions. The majority of train engines have been in service for more than 30 years. The locomotive cabin is usually not air conditioned, and the communication technology employed is relatively conventional. Train drivers are supposed to meet scheduled arrival times that are often difficult to achieve, in addition to usually hectic train stations. Job rosters, while usually planned weeks earlier, changes frequently causing irregular work-rest schedules.

The drivers also have to be very cautious when operating the train, since the railways are often not free from obstacles. These include people's houses that are only meters away from the tracks, business activities of the locals that are done on or along the railway tracks. For such conditions, accidents involving local people are frequent and inevitable, and commonly resulting in fatalities. Similar phenomena can also be found at railway crossings. There are currently about 4945 crossings, of which about half are not guarded and a considerable percentage are illegal crossings. Even at many guarded crossings, accidents still frequently occur. Poor behavior of road users that is associated with the accidents includes running the barrier (even after it has been completely activated), or inpatient motorists and heavy traffic that result in unmoving vehicles right on the railway crossings. Additionally, many business activities are often conducted very close to the crossings, including street vendors and public transportations waiting for passengers.

Despite these likely stressful work conditions, workload among Indonesian train drivers has rarely been investigated. Such work conditions could lead to excessive psychological stress, which in turn may result in cognitive failures (Day et al., 2012; Harris et al., 2008). These failures may include poor memory functioning, lapses in attention, or slower reaction times. Such dysfunctions could consequently result in human error (Cox & Griffith, 2005; Johnson et al., 2014) and greater safety risks (Clarke et al., 2013) during train operations.

Occupational stress has been studied by a number of researchers, and objective methods in evaluating stress have been proposed in the literature. The work of Yamaguchi et al. (2004) demonstrated the applicability of employing α-amylase as a marker of stress associated with occupational factors. This and other studies in this area (e.g., Nomura, 2007; Skosnik, 2000) have suggested an increase in α-amylase as a result of increased workload and stressful work conditions, which is controlled by the human autonomic nervous system. At present, the measuring apparatus is commercially available, and has been employed in a number of occupational settings. The objective of the present study was to utilize α-amylase in evaluating the level of workload and stress experienced by Indonesian train drivers. It was expected that findings of this study could be used as a basis for ergonomic improvement aiming at reducing excessive workload and stress among train drivers.

2. Methodology

A total of 36 (male) train drivers were recruited for the purpose of this study. They all agreed to participate in the study, and filled out and signed an informed consent form. The drivers typically work continuously for about three to four hours (one-way trip), with two trips usually assigned to the train drivers per day. The drivers were asked to fully cooperate in this study, but were allowed to withdraw from the study at any time. They performed their jobs according to their schedules, and were compensated for their participation in the study. This study was approved by the university's center for research and community services.

Levels of stress were assessed by measuring salivary α-amylase (SAA) obtained from the train drivers, before, during, and immediately following the end of a duty. The instrument for measuring SAA (Cocorometer, Nipro Co., Japan) was commercially available and was practical to use. Disposable test-strips were used and inserted into the mouth (for 20 seconds under the tongue), and later were attached back into the instrument. After a few minutes, the display would read the value (in kU/l), with moderate and highly stressful conditions were indicated by a value of greater than 45 and 60 KU/l, respectively (Yamaguchi et al., 2001; 2006).

In addition to measuring levels of occupational stress, mental workload was evaluated by using the Subjective Workload Assessment Technique (SWAT), which is a subjective method of measuring mental burden (Meshkati and Hancock, 1988). Using this method, non-physical workload can be classified into time, mental effort, or stress load dimensions. The time load was associated with planning, implementation, and monitoring tasks. Mental effort denoted the amount of effort needed in planning to execute a job, while stress load represented the amount of risk, confusion, and frustration associated with the tasks of train-driving. Unlike the SAA measurement, the SWAT was administered after a train driver had just finished completing a trip. It should be noted that all train drivers were informed and trained on the use of SAA measuring instrument and how to assess workload using SWAT. The train drivers were given a sufficient amount of time to complete SWAT, and were guided if there were confusions when using SWAT. Note that only 23 train drivers participated using this technique.

3. Results

Mean SAA from all 36 train drivers (across the three conditions) was 96.2 kU/l (SD ± 69.1). Levelof SAA prior to the driving task was 106.9 kU/l (SD ± 80.97). A significant (p<0.05) decline in SAA was observed for levels of SAA during (90.9, SD ± 52.48) and following the end of a trip (90.7 kU/l, SD ± 71.58). The box-plot showing the median of SAA is shown in Fig. 1 below.

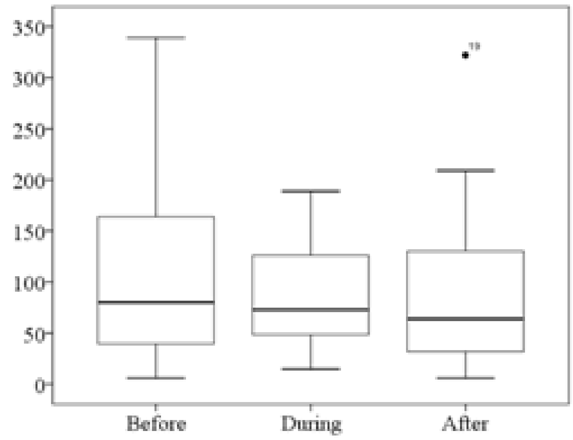

Figure 1: Levels of SAA prior to, during, and after a train trip.

When examined individually, changes in SAA levels demonstrated interesting phenomena. Assuming that a 10% changes in SAA was considered substantial, about half of the drivers experienced declining SAAs, while roughly 32% experienced an increase in SAA levels. While half of the drivers experienced a declining level of SAA, the average decline was only 38.8% (of initial SAA). This was in contrast to 215% changes in SAA (for those with increased SAAs). As a matter of fact, there were four drivers who experienced increased SAAs in the order of 300% – 600%.

When comparing SAA levels between during vs. after the trip, the results indicated that 44.1% of the drivers experienced increased SAAs, while 35.3% had declining SAAs. The absolute differences were not as great as those when comparing prior vs. during the trip. Overall, there was no consistent trend in SAA changes, but a number of drivers did show large changes (i.e. increased SAA).

Results obtained from SWAT demonstrated that a large percentage (a median of more than 60%) of workload was in the ―time" dimension (Fig. 2). The ―effort" dimension was reported by roughly 25% of the drivers, while the ―stress" dimension was reported by only about 10% of the drivers. Table 1 indicated list of activities before, during, and after a train trip. These activities were the driver's responsibility, and the majority of mental workload was associated with preparing and operating the locomotive.

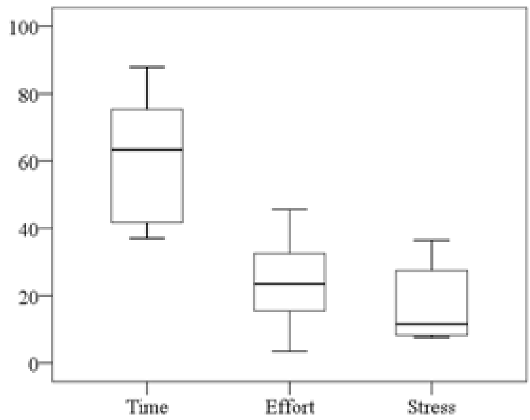

Figure 2: Workload of train drivers as assessed using SWAT.

Table 1: List of activities typically performed by a train driver

	Mental Workload			*Work element*	*Mental Workload*		
	Heavy	Moderate	Light		Heavy	Moderate	Light
Before assignment	2	4	17	-Arrive 45 minutes before departure, filling attendance list	6	1	16
				-Performing health check-up to receive recommendation from UUK	4	-	19
				-Handing over health recommendation to supervisor to receive STPD, LAPKA, T.100, and information on locomotive number.	4	-	19
				- Declare T.200 received is appropriate with locomotive operated and checking important notes in T.200 related with locomotive reliability	7	1	15
				-Performing locomotive check	3	3	17
				-Checking Minimum Equipment List and ensuring availability of No-Go Item	5	1	17
				-Turning on locomotive in accordance with procedure	3	4	16
				-Departing from Depot to station guided by departure officer	5	2	16
				-To report to PPKA/PAP to hand over LAPKA, checking important notes from PPKA and understood the notes.	2	1	20
				-Performing coach brake press	5	2	16
				-Performing static and dynamic brake testing	4	2	17
During assignment	2	6	15	-Carry out T.100 and LAPKA checking	2	-	21
				-Carry out accordingly, appropriate to the terrain passed	9	1	13
				-Monitoring locomotive indicator/ instrument to ensure functionality	8	2	13
				-Concentrate and aware of terrain/tracks passed	8	7	8
				-Carry out and ensure 21 slogan and coach condition in places visible to operators (on-condition check)	4	4	15
				-Point-and-mention every slogan and signs	5	2	16
				-Performing modulation check to PK/OC before locomotive operation and in every region switch.	3	3	17
				-Dynamic braking every 30 minutes	5	4	14
				-Locomotive examination during stops in station (if train stops for more than 5 minutes)	6	6	11
				-Negotiate small interference in locomotive)	10	1	12
				-Making decision, should locomotive/ train suffered inconvenience on freeway	10	3	10
				-Carry out coordination with PPKT through radio about expedition-related stuffs.	5	2	16
				-Filling out important logs in T.200 about locomotive condition	3	1	19
				-To deliver locomotive, coach, and braking condition verbally to substituting driver	4	1	18
After assignment	2	0	21	-Reporting locomotive condition verbally to pool and as a report in T.200	1	1	21
				-Report findings or occurrence during operation to supervisor	1	1	21
				-Over viewing and checking assignment for the next day	1	1	21

4. Discussion

The objective of this study was to evaluate the level of stress and the amount of workload experienced by Indonesian train drivers. Findings of this study demonstrated that the majority of train drivers experienced stressful work condition, as indicated by relatively high levels of SAA. In addition, time was one of the major factors contributing to higher mental workload among the train drivers.

Yamaguchi and colleagues (2004) have developed a criterion, in which an SAA level greater than 60kU/l to be considered as very stressful. In this study, about 71% of the drivers experienced a stressful condition even prior to driving the train. This figure dropped to about 59% (during the trip), and furthermore to 56% (after completing a trip).

It is somewhat unclear why the SAA levels were relatively high for these train drivers. There are, however, a number of possible explanations that can be offered here. First, there might be a number of factors that contributed to stressful condition prior to a train departure.

A large percentage of the drivers had fairly long commuting time (one to two hours). This commuting time could have introduced a source of stress, since they had to deal with traffic jams and a bit of uncertainty in reaching their office on time. This time pressure could certainly affect levels of SAA. In addition, most train stations in Indonesia are very hectic during operation hours. Incoming passengers could occupy any spaces in the train stations, and station officials (including train driver) have to deal with various unpredicted passenger behavior.

Second, a number of contributing factors were also present during train driving. Almost all of the train engines were over 25 years in service and moreover, none was equipped with appropriate air conditioning. It is likely that humid and high tropical temperature could create undue heat stress and unfavorable working environment. During the trip, the drivers also had to deal with many level train crossings, a large percentage of which were unguarded and even illegal. This could create additional mental burden since the drivers had to watch the traffic in a distance, and made difficult decision as whether the crossings were safe or not. This condition was exacerbated by the fact that many houses and local activities were very close (often done on) the railway track. These and issues noted earlier can be used as a basis for ergonomic interventions. For instance, the use of air-conditioned cabin could potentially reduce the amount of workload and stress.

Specific to the use of SAA as an indicator of occupational stress, results in this study indicated that the use of the SAA measuring instrument (employed here) might need to be investigated further. The instrument may not be as sensitive and as specific as expected. For example, results from this study indicated non-consistent trend across all drivers. Furthermore, the actual SAA values seemed to be much greater than those reported in the literature (e.g., Nozaki et al., 2009; Yamaguchi et. al., 2006). It is well accepted that SAA concentration is indeed a relatively rapid biological response (Rohleder and Nater, 2009), and many contextual (work and demographic) factors could influence salivary secretion. Based on results from the present study, it is suggested that the use of SAA (and the instrument used in this study) be evaluated further and, whenever necessary, SAA values should be calibrated against subjectively determined stress level for a certain population for a specific job. It is also suggested here that normative values should not be used as a sole criterion; changes in an individual is probably more meaningful for ergonomic intervention purposes.

5. Conclusion

This study was conducted with an objective of evaluating stress level and the amount of workload experienced by Indonesian train drivers performing their jobs. Salivary α-amylase was utilized as a means for determining level of occupational stress. Furthermore, Subjective Workload Assessment Technique (SWAT) was used for determining mental workload for the job. Results from this study demonstrated the fact that the job of a train driver was indeed stressful. The greatest amount of stress and workload was associated with activities prior to actual driving of the train (e.g., commuting from or to work, examining/checking the readiness of the locomotive, or performing break checks). There was, however, no particular trend in SAA values that could be observed over time. Several individuals showed substantial increase in SAA values, particularly when comparing between ―prior" vs. ―during" train driving. It is suggested here in this study that the use of SAA and the corresponding instrument be evaluated for its sensitivity and specificity. Calibration of SAA level against subjectively determined stress level for a particular work population is also suggested, for the purpose of developing appropriate normative values for the population.

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