



## **Workplace Noise Induced Plasma Cortisol in Some Workers of Thoothukudi**

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### **ABSTRACT**

The effects of work environmental noise and perceived stress on early morning free cortisol levels after awakening were investigated in a group of workers. Previous studies revealed that cortisol levels showed a significant increase after awakening, with high intra individual stability. The aim of this study is to evaluate whether Workers exposed to environmental noise and possible psycho-social stressors could be at risk for alterations on plasma cortisol levels compared to a control group in Morning and Evening. Plasma cortisol levels were determined in 100 Construction workers, 100 Teachers and 50 Drivers. The mean cortisol values of different workers were significantly higher when compared with the control of both male and female. The mean cortisol level detected both in morning and evening were very high in Workers when compared to the Controls. The authors hypothesise an effect on plasma cortisol levels in workers exposed to environmental noise and possible psycho-social stressors.

**Keywords:** Cortisol, Work environmental noise, Stress.

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## INTRODUCTION

Noise is an increasing problem in our environment nowadays, especially the kind of “unwanted sounds” that influence our well-being and health negatively. Exposure to noise is not specific to workers in industries and can be present in many rest-related activities and ambient conditions such as transportation (WHO, 2000)<sup>1</sup>. A lot of studies demonstrated that traffic noise as a stressor can cause discomfort, sleep disorders and can disturb daily-life activities (Gayathri *et al.*, 2012; Evans, 2001; Ising and Kruppa, 2007; Maschke and Hecht, 2007; Griefahnet *et al.*, 2008; Michaud *et al.*, 2008; Selander *et al.*, 2009; Waye *et al.*, 2002)<sup>2,3,4,5,6,7,8,9</sup>. Several studies have demonstrated an increased secretion of salivary stress biomarkers like the salivary alpha-amylase (sAA), salivary chromogranin A (sCgA) and salivary cortisol (sC) under different stress conditions (Takai *et al.*, 2004; Miyakawa *et al.*, 2006; Nater *et al.*, 2006; Hebert and Lupien, 2007; Filaire *et al.*, 2009; Hellhammer *et al.*, 2009; Lewis, 2006)<sup>10,11,12,13,14,15,16</sup>. A vast variety of evidence demonstrated that noise is one of the most common occupational hazards of the modern world, and this general and non-specific stressor, which affects millions of workers worldwide, can result in psychological distress symptoms and physiological reactions (Kjellberg, 1990; Melamed *et al.*, 1992; Melamed and Bruhis, 1996)<sup>17,18,19</sup>. Exposure to noise is not only specific to working in industries, but also it can be present in many leisure-related activities and ambient conditions such as transportation (WHO, 2000)<sup>1</sup>. Activation of the hypothalamic-pituitary-adrenal axis (HPA) and subsequent secretion of cortisol are considered as major components of the physiological stress response in humans (Ockenfels *et al.*, 1995)<sup>20</sup>. In some of the studies, saliva and/or serum cortisol were assessed as a stress hormone (Selander *et al.*, 2009; Waye *et al.*, 2002; Bigert *et al.*, 2005; Laudat *et al.*, 1988; Vining and McGinley, 1987; Walker, 1984)<sup>8,9,21,22,23,24</sup>. Cortisol is the major glucocorticoid produced in the adrenal cortex (Carrasco and Van de kar, 2003)<sup>25</sup>. Cortisol production has a circadian rhythm, with levels peaking in the early morning and dropping to the lowest values at night (Dickmeis, 2009; Dorn *et al.*, 2007; Hucklebridge *et al.*, 2005)<sup>26,27,28</sup>. Levels rise independently of circadian rhythm in response to stress (Filaire *et al.*, 2009; Miller *et al.*, 2007; Nater *et al.*, 2007; Poll *et al.*, 2007; Raggam *et al.*, 2008)<sup>14,29,30,31,32</sup>. Stress can be defined as the physical, emotional and mental strain resulting from the mismatch between an individual and the environment (Bynoe, 1994)<sup>33</sup>. Stress is most likely to occur in situations where; demands are high, the amount of control in an individual is low, and there is limited support or help available for the individual. When a body receives stressor, it can increase the stress level (Richard and Christine, 1989; Kyriacou and Sutcliffe,

1978)<sup>34,35</sup>. Noise is a non-specific stressor, which affects millions of workers worldwide, resulted in psychological distress symptoms and physiological reactions (WHO, 2000; Selander et al., 2009; Waye et al., 2002; Kjellberg, 1990; Melamed and Bruhis, 1996; Melamed et al., 1992)<sup>1,8,9,17,18,19</sup>. Cortisol is well known as a marker of diurnal rhythm (Born and Fehm, 2000)<sup>36</sup>. The hormone follows a 24 hour rhythm with peak levels usually found in the first 30 to 60 minutes after awakening and decreasing levels thereafter (Wilhelm et al., 2007)<sup>37</sup>. Salivary cortisol levels follow very closely to plasma levels, and like plasma levels they are very sensitive to psychological factors (Kirschbaum and Hellhammer, 1994)<sup>38</sup>. Saliva cortisol sampled immediately after awakening and during the working period is a good indicator for any changes in diurnal rhythm associated with different working schedules (Harris et al., 2010; Costa, 1996; Pilcher et al., 2000; Barnes et al., 1998; Bjorvatn et al., 2006)<sup>39,40,41,42,43</sup>. High levels of industrial noise considered to be main stressor and its interference, can be accessed via monitoring salivary cortisol in exposed individuals (Smyth et al., 1998)<sup>44</sup>. The present study was designed to measure and compare plasma cortisol concentrations in the morning and evening in normal working day in various workers. The work further designed to assess the association between industrial noise exposure and plasma cortisol concentrations in various workers in relation to sex and experience.

## MATERIALS AND METHODS

The noise level in the working environment of the different workers studied in the present work was executed with the help of the Sound Pressure Level Meter (Model-LT-Lutoon-SL-401, Made in Taiwan), 1/2in Condenser Microphone (Type - 4226) and 1/3- Octave filter with frequency range and measuring level range of 31.5 Hz – 8 KHz and 35 – 130 dB with the accuracy of 0.5 – 1dB. A questionnaire developed by Boyle et al., 1995<sup>45</sup> was used to measure the Stress level of the workers. The questionnaire uses Likert Scale in the evolution of responses were by 0 mark was given for “Never”, 1 for “Seldom”, 2 for “Sometime”, 3 for “Often” and 4 for “Regular”. The total score was categorised into Normal (0 - 20), Mild (21 - 45), Moderate (46 - 70), Severe (71 - 90) and Very severe (>90). With the help of Doctors and Technicians of Thoothukudi Medical College Hospital, 10 ml sample of venous blood was taken from each worker at about 8am in the morning, immediately after awakening and another sample at the time of completion of their work in the evening. The workers were properly intimated regarding the collection of blood. The sample was collected only from the accepted workers. Samples were immediately transferred into an EDTA coated test tubes and the tubes were carefully shifted to

the laboratory in a thermo cool box. In laboratory the samples were immediately centrifuged and the serum was stored at  $-20^{\circ}\text{C}$  until analysis. A total of 250 workers with different categories were included in the study underwent RIA (radioimmunoassay). The normal values of the test were the ones applied in our laboratory, 138–690 nmol/l for both sexes (cortisol values at hour before 12pm). The laboratory did not know which samples came from the group of which workers and which from the control group, although the physicians, technicians and the scholar knew how the study was being carried out. All of the subjects consented to their personal details being available, declaring that they had been made aware that this data is ranked as “sensitive information”, and consented that the data arising from the research protocol should be treated in an anonymous and collective way, with scientific methods and for scientific purposes. Statistical analysis of the data was based on the calculation of the mean, standard deviation and range according to the nature of the single variables. The differences between the means were compared using Student’s ‘t’ Test for the unpaired data. Analyses of the variance (ANOVA) were done to compare the means between three group of workers. Both the data analysis and statistical calculation were made using Microsoft excel equation version 6.1.

## RESULT AND DISCUSSIONS

The excessive noise level in the working environment is considered to be the stressor since it affects the general health of the workers to a greater extent (Swanson and Naomi, 2000; Dalton *et al.*, 2002; Angerer, 2003; Garssen, 2004; Copper, 2004)<sup>46,47,48,49,50</sup>. The noise stressor generally affected the physiological and psychological health study of the workers such as sleeplessness, body pain, headache, increased blood pressure, increase of glucose and lipid profile, increase of stress hormones and so on (Gayathriet *al.*, 2012;Zamaniaet *al.*, 2013;Attarchiet *al.*, 2012;Babisch, 2011;Guoxia *et al.*, 2006; Haines *et al.*, 2003)<sup>2,51,52,53,54,55</sup>. In the present study, the workers studied exposure to  $>80\text{dB}$  of sound for more than 8hrs/day. The noise level observed in various work sites ranged between (59.4 - 108.0 dB) during all the working hours (Table-1).

The prolonged exposure resulted in severe stress conditions among both sexes of different categories of workers. Among females about 17.75, 15.1% of teachers, 26.7, 20% of Construction workers and among males 23.9, 17.9% of teachers, 25.4, 26.5% of Construction workers, 15.3, 52.7% of Drivers were affected by stress severally and very severally respectively. The study result clearly indicated that the drivers were the most affected followed by Teachers and Construction workers (Table-2).

**Table 1: The Minimum, Maximum and Mean noise level (dB) observed from different work environment of Thoothukudi city at different time intervals. The values indicated are the mean of hundreds of observations**

Workers	Location	Time Interval											
		09.00 – 11.00			11.00 – 01.00			01.00 – 03.00			3.00 – 05.00		
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Teachers	School	65.1	87.13	<b>79.21</b>	66.3	88.9	<b>82.31</b>	68.7	84.5	<b>80.70</b>	67.5	89.7	<b>84.50</b>
	College	59.4	97.5	<b>72.23</b>	52.6	91.5	<b>73.07</b>	54.6	84.1	<b>73.61</b>	48.6	79.3	<b>71.13</b>
Drivers	Heavy Traffic Area	97.9	101.4	<b>99.70</b>	101.9	106.2	<b>104.1</b>	85.2	98.1	<b>91.70</b>	106	109.9	<b>108.0</b>
	Commercial Area	81.1	92.5	<b>87.10</b>	86.7	93.0	<b>89.90</b>	85.7	95.1	<b>91.70</b>	83.3	96.9	<b>94.40</b>
Construction Workers	Construction Sites	62.4	90.2	<b>72.59</b>	65.9	91.6	<b>84.10</b>	70.8	95.6	<b>86.49</b>	86.3	96.3	<b>90.79</b>

**Table 2: Stress level in overall male and female workers**

Workers	Overall Female				
	Normal 0 – 20	Mild 21 – 45	Moderate 46 – 70	Severe 71 - 90	Very severe >90
Teachers (271)	51 (18.82)	72 (26.57)	59 (21.77)	48 (17.71)	41 (15.13)
Mean ± SD	10.08 ± 6.06	32.88 ± 7.72	61.31 ± 6.77	80.44 ± 5.36	118.54 ± 24.02
Construction workers (165)	26 (15.76)	26 (15.76)	36 (21.82)	44 (26.66)	33 (20)
Mean ± SD	10.31 ± 5.11	32.38 ± 5.63	54.94 ± 6.03	77.93 ± 5.78	110.48 ± 10.19
Workers	Overall Male				
Teachers (201)	40 (19.9)	38 (18.9)	39 (19.4)	48 (23.88)	36 (17.92)
Mean ± SD	14.65 ± 4.83	30.47 ± 7.79	55.62 ± 6.39	69.98 ± 9.83	108.72 ± 15.71
Construction workers (185)	24 (12.97)	24 (12.97)	41 (22.16)	47 (25.41)	49 (26.49)
Mean ± SD	10.33 ± 5.99	32.83 ± 5.45	56.28 ± 6.56	79.67 ± 5.97	115.78 ± 9.59
Drivers (150)	8 (5.33)	26 (17.33)	14 (9.33)	23 (15.33)	79 (52.68)
Mean ± SD	13.63 ± 6.12	33.15 ± 7.36	55.57 ± 4.91	79.91 ± 4.67	130.29 ± 17.23

This much of prolonged stress resulted in a significant elevation of the stress hormone cortisol in the blood of workers during both the study period. In relation to the stress conditions, the plasma cortisol of the workers was also significantly increased in the present study. In case of the control population the cortisol level observed both during morning and evening was within the stipulated limit. But the study result showed that there was a significant steep raise of cortisol in the plasma

of both the sexes of teachers, Construction workers and Drivers both in morning and evening. The cortisol level showed further increase in the evening in all workers immediately after the completion of their work (Table-3).

**Table 3: Cortisol level in Workers**

Workers	Morning		Evening	
	Male	Female	Male	Female
<b>Control (N=100)</b>	<b>147.34 ± 24.46</b>	<b>146.19 ± 20.13</b>	<b>147.80 ± 38.74</b>	<b>145.36 ± 7.90</b>
<b>Teachers (N=100)</b>				
<b>Mean ± SD</b>	268.54 ± 63.27	295.78 ± 66.23	313.58 ± 82.37	323.46 ± 81.27
<b>% Increase</b>	82.26	102.33	112.17	122.52
<b>Z Test</b>	13.54	15.97	14.23	15.50
<b>Construction Workers (N=100)</b>				
<b>Mean ± SD</b>	239.59 ± 48.90	271.44 ± 39.21	268.15 ± 62.99	296.51 ± 36.82
<b>% Increase</b>	62.61	85.67	81.43	103.98
<b>Z Test</b>	13.34	22.59	13.51	29.02
<b>Drivers (N=50)</b>				
<b>Mean ± SD</b>	330.42 ± 71.77	-	383.77 ± 76.25	-
<b>% Increase</b>	124.26		159.65	
<b>Z Test</b>	18.04		21.88	

The study result concluded that due to severe stress created by the prolonged noise, the stress stimulating hormone cortisol was significantly increased in the blood plasma of all categories of workers studied. The study result further concluded that continuous exposure of the workers to very high noise (59.4 - 108.0 dB) is the main causative stressor responsible for a steep increase of cortisol in their blood both in morning and evening (Hebert and Lupien, 2009)<sup>56</sup>. In the present study most of the workers were habitual drunker and smokers. Such a workers when exposed to the noise >80dB in their workplace for more than 8 hours per day regularly resulted in several physiological alterations such as sleeplessness, high Bp, high cholesterol and also increase of cortisol level in the blood plasma which in turn enhances the cortisol level in saliva, sweat and urine. Gitanjali and Ananth (2003)<sup>57</sup> performed a study in which healthy individuals exposed to loud occupational noise during daytime would cause changes in their nocturnal sleep, architecture, heart rate and serum cortisol level. Miki et al., (1998)<sup>58</sup> assessed the urinary and salivary stress hormone levels while performing arithmetic calculation in noisy environment showed higher cortisol levels during performing the task in noisy environment in comparison with pre task levels of cortisol and the cortisol in quite condition. Jarupet al., (2008)<sup>59</sup> reported a

significant increase in cortisol level in the morning samples for women exposed to aircraft noise that also induced the risk of hypertension. Several previous studies on the traffic noise exposure in relation to hypertension, cardiac disfunction, irrespective of sex showed a significant increase in cortisol both in blood and saliva (Selanderet al., 2009; Jarupet al., 2008; Babischet al., 2005; Belojovicet al., 2008; Willichet al., 2006)<sup>8,59,60,61,62</sup>. Generally the shift workers are in stressful conditions which affect their body performance to a greater extent (Zamanianet al., 2010; Allan and Czeister, 1994)<sup>63,64</sup>. Staying awake during unusual hours altered the sleep and wake cycle, further, the workers exposed to high noise level for several consecutive days affects endogenous circadian rhythm including disturbance in sleep, body temperature, cortisol level and so on (Allan and Czeister, 1994; Youngstedt et al., 2002; Kalleberg, 2003)<sup>64,65,66</sup>.

## CONCLUSION

The study concluded that continuous exposure of the workers to high level of noise for long duration become a stress on them which triggers the hormonal system resulted in Insomnia and other Physiological disturbances.

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