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Effects of physical environment factors on worker's health in micro and small sized industries of Pakistan

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Abstract

Background: Physical and environmental factors can affect both job performance and job satisfaction of the workers. Despite of the progress and improvement made for occupational safety and health, work environment especially in low and middle income countries is still hazardous for the workers. A large number of work related injuries and occupational accidents happens around the world each year. This research project aims to map work environment conditions and impact of physical environmental factors on occupational health in Punjab – Pakistan.

Methods: Total eight micro and small industries in Lahore and Gujaranwala were visited during winter and summer season separately. Physical factors of light, noise and temperature were recorded for six hours during winter. A quantitive questionnaire was filled from 138 workers and an inspection of workplace was made by using ILO ergonomics checklist. Modified Testo 177 and Lascar data loggers were used to measure air (ta), globe (tg), natural wet bulb (tnw) temperatures and relative humidity (RH) to calculate the WBGT index.

Result: Mean age of workers was 28.6 ± 10.5 years working for 8.8 ± 1.5 hours a day at a metabolic rate of 165 W/m^2 (ISO 7243 level of exertion) and had 0.5 – 1 hour rest. In cold season the average indoor WBGT was 16.0 ± 2.5 ºC and in hot season the average indoor WBGT was 29.9 ± 5.5 ºC and indoor air velocity was 0.7 ± 0.3 m/s. Noise was recorded for time weightage average (TWA) and recorded a range of 73.1 dB (A) to 91.7 dB (A). Minimum intensity of 41.5 lux for light was recorded in one industry.

Conclusion: A noise level of less than 85 dB (A) and light of 400 lux to 800 lux will improve physical and psychosocial work environment. Heat stress monitoring policy can be implemented by using ISO 7243. ILO ergonomic checklist can prove an important tool to make assessment and recommendations for working environments in Pakistan.

Key Words: WBGT, Physical and environmental factors, Occupational health

Contents

1. Background

Physical and environmental factors can affect both job performance and satisfaction of the workers. Despite of the progress and improvement made for occupational safety and health, work environment especially in low and middle income countries is still hazardous for the workers. Schulte and Chun conceptualized a model to highlight the link between climatic factors and occupational safety and health. According to this model factors of population growth, energy policies, increase urbanization and deforestation are not merely causing the global climate change but also affecting the health of workers. Workers are more exposed to high ambient temperature, increased air pollution, ultraviolet radiations, extreme weathers and vector born diseases. These hazards are causing heat stress illness, respiratory, cardiovascular, musculoskeletal and psychological problems to the workers both in and outside of the work place (Schulte & Chun, 2009).

A large number of work related injuries and occupational accidents happens around the world each year. According to International Labour Organization (ILO) approximately 200,000 workers lose their lives each year and an approximate figure of 120 million workers encounter with injuries or work induced illness across the globe (Forastieri, 2002). In 2003 the number of fatal occupational accidents was 337 million along with 160 million affected workers from occupational diseases (Al-Tuwaijri, et al., 2008). Economic cost of occupational safety and health problems creates competitive and financial burden on both the country and enterprises (Niu, 2010). An average amount of over four percent of total gross national product of all the countries in the world can be decreased due to work related diseases and injuries to compensate for productivity loss, premium insurance and medical expenses (Takala & Niu, 2003). Occupational injuries not only cause human damage but also cost in production and efficiency of the affected company.

Occupational environment can be categorised into psychosocial and physical factors. The concept of psychosocial was brought up in 1978 Work Environment Act, according to which an individual is considered as a bio psychosocial, reactive and active to their surroundings environment. Thus an individual can be affected by its work environment which can affect their well being and productivity at work (Thylefors, 2009). Physical factors are those which can be expressed in physical quantities such as noise, vibration, light, thermal climate and radiation. Physical factors not merely mean that it will only affect an individual physically but can also have a significant impact on wellbeing and comfort, performance and the risk of accident (Bohgard, et al., 2009).

Vischer's study on work environment and stress found that worker's job performance and satisfaction being affected by physical and environmental factors in which they are working (Vischer, 2007). Occupational life is strongly related with these factors for example good lighting not only contributes to good visual ergonomics but can also reduce the risk of accidents and can prevent poor postures (Bohgard, et al., 2009). A worker can be exposed to multiple factors at the same time. For example a welder may be exposed to difficult working postures, high light intensity, ultraviolet radiations, welding smoke, gases and noise. These factors can cause eye irritation, respiratory, musculoskeletal and psychological problems to an exposed worker (Bohgard, et al., 2009). Individual factors of age, obesity, pre-existing disease, body size, and immunological status, type of clothing and genetic characteristics can exacerbate the risk of health hazards on the worker (Schulte & Chun, 2009).

1.1. Micro and small entrepreneur

European commission has defined micro and small entrepreneur on the basis of number of employees and the financial turnover per annum. Micro entrepreneur are estimated to have employees less that 10 with a maximum annual income turnover to 2 million Euros. Small sized entrepreneur have employees up to 50 and can have a maximal annual income turnover of 10 million Euros (EU, 2005). Pakistan is a developing country with rapid industrialization in the recent years in which small and medium sized enterprises (SME) plays important role.

According to Chemin SMEs with less than 100 employees constitute 90 percent of private industrial sector of Pakistan with 30 percent of national GDP (Chemin, 2008).

1.2. Noise and workplace

Noise can be defined as undesirable sound to which an individual is exposed. Differentiation between the desirable and undesirable sound depends upon various factors including time and duration, character of the sound and worth of the information containing in that sound (Bohgard, et al., 2009). Excessive noise exposure can cause various physiological and psychological problems including increased blood pressure, reduction in performance, insomnia and short temperedness (Nelson, et al., 2005). Average noise level over a specific duration is time weightage average (TWA) usually measured in equalvent sound level which is expressed as dB (A) (Bohgard, et al., 2009). National Institute for Occupational Safety and Health (NIOSH) has recommended an exposure limit of 85 dB (A) for a maximum exposure time of 8 hours on a working day (NIOSH, 1998). Noise limit values are different in developed and developing countries which can vary from 85 dB (A) for developed countries as compared to 90 dB (A) in developing countries. Due to rapid industrialization, high noise intensity, longer exposure time and not accompanied by protection, workers of these regions are more vulnerable to develop occupational induced hearing problems and related diseases (Concha, et al., 2004). International labour organization has also recommended the same noise level of 85 dB (A) to 90 dB (A) for a worker during an eight hour of daily shift. Exceed to this limit can cause various physiological and psychological problem in the worker (ILO, 2010).

According to Smith, hearing loss in adults is estimated from 120 million in 1995 to 250 million in 2004 worldwide and can be described as fifteenth most serious problem in the world which can cause additional effects of social isolation and serious national economic burden (Smith, 2004). Smith found that most of the hearing loss in these adults was related with high occupational noise level. High level of noise in occupational settings is a universal problem.

According to National Institute for Occupational Safety and Health (NIOSH) in United States of America alone there were around 30 million workers exposed to hazardous noise in 1998 (NIOSH, 1998).

1.3. Light

Lighting is an essential element to the health and safety of workers at the workplace. Light allows an individual to gather the information from its surrounding, and determine the size, shape, colour and movement. Sufficient light makes it more easy for the workers to work and can prevent accidents. Light environment and visual ergonomics are two main concepts that can be used to monitor the light condition at a workplace. European standard suggested that for moulding, machine work the intensity of light should be 300 lux and required higher light intensity of around 2000 lux for fine precision work (Bohgard, et al., 2009). There are some other light related hazards which can adversely affect the health and safety of the workers. These factors include lighting effects, incorrect lightening design and poor installation of lightening source which can cause disability glare from a light fitting, colour effects and distracting reflection (HSE, 2002).

1.4. Temperature

Causalities at military training centre in USA due to heat were reported by Yaglou and Minard in 1957 with the purpose to define the limits for safe physical exertion and hot environmental conditions to control the causalities. The selected mechanism to control heat causalities was a simple heat stress index called Wet Bulb Globe Temperature (WBGT) which is widely used in the world now to control heat stress in military, industrial, domestic, sporting and commercial settings. WBGT makes its reputation at national (e.g. UK, China, Japan, USA, Australia etc) regional (e.g. Europe) and international (ISO) standards (Parson, 2006). The parameters for calculating WBGT index are natural wet bulb temperature (t_{nw}) and globe temperature (t_g) for indoors and it also includes the air temperature (t_a) for measuring the outdoor WBGT Index. The following equations show the relationship between different parameters to measure WBGT Index (ISO 7243, 1989).

Inside building and outside buildings without solar load;

WBGT= 0.7 t_{nw} + 0.3 t_g .... Equation 1

Outside buildings with solar load;

WBGT= 0.7t_{nw} + 0.2 t_g + 0.1 t_a .... Equation 2

Heat stress presents a great problem for the people who work in tropical and subtropical areas. Sometimes industrial climates have high temperature settings to which the workers are exposed (Noweir, et al., 1996). Heat illness can be categorized into heat cramps, heat exhaustion, heat syncope, exertion hyponatremia and heat stroke (Cooper, et al., 2006, Binkley, et al., 2002). High physical activities with high thermal resistant clothing impede the cooling mechanism of the body and increase the metabolic heat production (Grundstein, et al., 2010). Core body temperature of 37 °C is considered as normal which is liable to increase with the physical activity and metabolic heat production within the human body. Excessive heat produced in the body has to be dissipated to the external environment to maintain the normal core body temperature. Six fundamental factors including air temperature, radiant temperature, humidity, wind speed, clothing and metabolic heat generated by physical activity determine the body heat balance. Heavy clothing or increased physical activities contribute to increase core temperature and may lead to heat stroke or death in extreme conditions. Heat stroke can occur at a core body temperature greater than 40 °C along with other body organs and system failure due to hyperthermia (Binkley, et al., 2002).

ISO 7243 standard second edition 1989 mapped thermal exposure limit values by making a comparison of metabolic rate and the exposure time for the worker (ISO7243, 1989). Figure 1 show the graph to determine the safe limit exposure value for the workers depending upon WBGT and metabolic activity of the worker. With the increase in WBGT the resting time should increase in order to prevent workers from heat illness (ISO7243, 1989). Resting time will allow them to disseminate their body heat, lowering the metabolic rate and taking fluid and food to prevent them from dehydration and hypoglycaemia.

This study is focused on mapping of physical factors especially noise, light and thermal environment to which a worker is exposed and how these factors are affecting worker’s health in micro and small sized manufacturing industries of Lahore and Gujranwala cities of Pakistan. We also used ILO ergonomic checklist to estimate work environment condition and reliability of this list in SMEs of Pakistan.

2. Methods

Data was collected for a working day from eight micro and small manufacturing industries during the month of February (winter season) and July (summer season) 2012 from north east of Punjab Pakistan including Gujranwala and Lahore cities. A consent form was requested to sign by industry owner for data collection. Quantitative data from 138 workers was collected during winter season with selection criteria of workers present on the day of measurement and age of 17 to 65 years. Workers were asked for subjective responses of their own health and well being in the questionnaire (Appendix 1). Workers were asked for subjective exertion level for daily work load and were also monitored for their physical activities to classify their metabolic rate according to ISO 7243.

Each SMEs was first visually surveyed through a walk through survey in order to get familiar with the industrial area and to pin point the working stations to record data and to place the tripod stands. Tripod stands were used to place the equipment and maximum of four stands were used in any industry. Data for noise, light and temperatures of air (ta), natural wet bulb (tnw) and globe (tg) and relative humidity (RH), were recorded from 10:00 to 16:00 in winter for each industry. Expected to be physical factors remained same we only recorded ta, tnw, tg, RH and air velocity during summer. Same procedure was followed as that of winter to calculate WBGT for summer. Following equipments and methods were used to measure data.

2.1. Impulse integrating sound level meter

Noise intensity was recorded by using Quest technologies impulse integrating (2500) sound level meter. Meter was set for 70-140 dB range to prevent misinterpret displayed values. Meter control 1 was set at "Run" and control 2 was changing to "SPL" and "LEQ". SPL mode was used to measure momentary noise intensity at every work station by holding the meter for 10 seconds after each one hour. Mode "LEQ" was used to measure time weighted average of noise in the factory for each one hour. Meter was placed periodically on different tripod stands placed near working stations after each 30 minutes to measure the average noise intensity for each one hour in the industry. Quest sound level meter has the ability to update reading at a rate of once per second[1].

2.2. Hanger digital luxmeter

Light intensity was measured by using Hanger digital luxmeter; model EC1 which has the capacity to measure light over a range of 0.1 – 200,000 lux with an accuracy level of ± 3 %.

[1] http://questtechnologies.com/Assets/Documents/1500_2500_Manual.pdf

Meter has four control ranges position to measure light and it was set at 1 lux in our measurements[2]. Light intensity was measured for every work station in the industry after each one hour. Meter was held over work station for 10 seconds and then average value button was pressed to get momentary light intensity value. Same procedure was repeated for every work station and the average of momentary values was calculated to get the light intensity level in the industry for each hour.

2.3. Testo loggers

Testo loggers (177-T4)[3] with an accuracy of ± 0.5 ºC along with three thermocouple wire sensors of type T. Two thermocouple sensors were connected to 5 cm globe and natural wet bulb sensor to measure tg and tnw. One thermocouple sensor was hanging in shade with aluminium cover to protect it from direct solar radiation and to measure ta. Data was recorded for each 10 seconds for 6 hours starting from 10:00 to 16:00. These parameters were measured to calculate WBGT according to ISO 7243. For the small globe sizes, the tg was corrected for the relative influence of air temperature ta, and mean radiant temperature tr (all temperatures in °C), for different air velocities va (m/s) and globe diameter D (150mm) by using the equation as recommended in ISO 7726.

$$tr = \left\{(tg + 273)^4 + \frac{1.1 \text{ x } 10^8 \text{x va}^{0.6}}{\varepsilon g \ x \ D^{0.4}} \ (tg - ta)\right\}^{0.25} - 273 \ldots\ldots \text{ Equation 3}$$

Where,

εg = mean emission coefficient of the globe = 0.95 (matt black globe)

tr = Radiant temperature.

D = Diameter of the ball

2 http://www.hagner.se/pdf/ec1.pdf

3 http://www.testo.com/online/abaxx-?$part=PORTAL.INT.ProductCategoryDesk&$event=show-from-content&externalid=opencms%3A%2FProducts%2FMeasurementParameters%2Ftemperature%2FMessgeraete%2FDatenlogger%2Ftesto_177-T4%2FEnglisch.product

Each Testo 177 was placed on a tripod stand at a height of 100 cm from ground and globe temperatures were recorded at 120 cm from ground for every measurement.

2.4. USB data logger

EL-USB-2-LCD humidity, temperature and dew point data logger with LCD were used to collect the data for air temperature and relative humidity. USB data loggers were set up according to Testo 177 and configured to record data from 10:00 to 16:00 for each 10 seconds. Data loggers were placed in shade together with Testo 177 to measure indoor climatic conditions and one data logger was placed outdoor in an aluminium shielded cover to measure outdoor air temperature and relative humidity[4].

Instruments were placed close to work station at a convenient position with suggestion and permission from workers to measure physical and environmental factors to which workers were actually exposed. Number of Testo 177 and indoor USB data loggers used was related to the number of active working units in the industry. Maximum of four data loggers and Testo 177 were used in some industries to collect the data from different working units and rooms in the industry.

One Quest technologies impulse integrating (2500) sound level meter and one Hanger digital luxmeter; model EC1 was used to collect the required data. Air velocity was measured for summer season by using air flow and volume flow meter with serial number 93945. Three minutes average air velocity was measured for morning (10:00), noon (13:00) and after noon (15:00) sessions by placing the instrument close to the working stations.

[4] http://www.lascarelectronics.com/temperaturedatalogger.php?datalogger=375

2.5. ILO Ergonomic checklist

International labour organization checklist for ergonomics was used for each work premises and selected points were utilized for physical work, light, working climate, noise and protection evaluation. A score with “No” referred to the satisfactory field area in the factory and “Yes” recommended some improvement in the available facility. “Priority” referred to prompt consideration in improving the work condition. Out of 132 checkpoints in the ILO checklist we selected 32 points related to physical work, lighting, climate, noise and protection methods at the work place as shown in Appendix 2. Factories scored high with “No” refer to better working conditions in contrast to factories scored higher in “priority” category.

3. Results

Out of eight manufacturing industries there were six micro and two small industries based on the number workers employed. Mean age of 138 workers was 28.6 ± 10.5 years with 72.5% non smoking habit and 43.5 % illiteracy rate. Workers start working in early ages of their life and 70 % of them had more than 5 years of work experience. Subjective physical exertion level was described as moderate with 66.7% of the workers were having 165 W/m^2 according to ISO 7243 reference table of metabolic rate level classifications. Out of 138 workers only 1 worker reported dissatisfaction toward his work and rest of the workers showed their gratification to continue the same work in future. Rest duration under a working day varied from 0.5 to 1 hour in an eight hours normal working day and it remained the same for both winter and summer seasons. There was no change in the opening and closing hours of the industries during different seasons. On an average a worker was having 8.1 ± 1.36 hours sleep at night. Subjective response of the workers about their health showed musculoskeletal (20.5%), respiratory (5.1%), auditory (3.6%), visual (12.3%) and cardiovascular (5.1%) health problems.

Recorded light, noise and temperature parameters were used to relate the incidence of above mentioned health problems. The data for workers in each factory and their health related problems are presented in Table 1 together with physical factors and ILO ergonomic checklist. We measured light levels at work place which ranged from 41.5 lux to 1063.3 lux. Minimum intensity of 41.5 lux showed 50% of the workers with visual problems in industry number 6 and highest light intensity of 1063.3 lux was measured in industry number 8 which had 9% of visual impaired workers.

Noise intensity of 73.1 dB (A) to 91.7 dB (A) was recorded. Mean noise intensity for all factories was recorded as 83.6 ± 7.2 dB (A). Variation in the WBGT between summer and winter was from 16.0 ± 2.5 ºC to 29.9 ± 2.5 ºC. Indoor air temperature showed a difference of 15.7 ºC and relative humidity difference of 11.4 %, Outdoor temperature difference between two seasons was 19.7 ºC as shown in Table 2.

4. Discussion

Occupational and health safety analysis in micro and small industries is difficult to manage and report because these industries do not register the accidents occurred at the work place and the number of accidents declared is low because of their small work force (Champoux & Brun, 2001). Health promotion activities to improve the physical and psychosocial work environment should involve both individual and organizational level. ILO ergonomic check list score showed that SMEs in Pakistan do not meet the standard criteria and needs to improve the working environment on a priority level. A comparison of ILO score with incidence of health problem in SMEs in Table 1 show that with higher points in “Priority and Yes” category the percentage of health related problem was also high. Among these health problems physical and visual problems were recorded with highest percentage because of poor postures of workers, low light at working station, more than 8 hours exposure time and less time to relax in between their work. Factors like repeated or forceful efforts, continuous static load, unstable working posture and vibration can cause musculoskeletal disorders (MSD), psychological problems, eye strain with developing headache and visual problems in the long run (Niu, 2010). Punnet has reported that MSD can even occur if a worker is exposed to such risk factors for 25% or less on a working day (Punnett, 2000).

Continuous physical work for more than 8 hours a day in a noise intensity greater than 85 dB (A) made the workers prone to develop physical, psychological and various health problems. One study on polyester fibre plant in Pakistan recorded an average noise level of 93.2 dB (A) with highest noise intensity of 99.5 dB (A) at the compressor house (Shaikh, 1996). Shaikh recommended engineering controls and hearing conservation along with hearing protection devices to control negative impact of noise on the workers. According to our findings factories with an average noise intensity of around 90 dB (A) had higher percentage of workers who reported hearing problems. These workers had no protection against noise and were unaware of the noise induced hearing impairments and related health hazards. National Institute for Occupational Safety and Health (NIOSH) has recommended time weightage average for eight hours work (TWA) limit of 85 dB (A). According International Standard Organizations hearing impairment risk increases to of 21 % at noise intensity greater than 85 dB (A) (NIOSH, Revised criteria 1998). Results of our study suggest similar TWA noise limit exposure value of 85 dB (A) for worker as industries with noise intensity greater than 85 dB (A) had higher percentage of hearing impairment. Long exposure time, no use of noise protective equipment and unawareness of the noise induced hearing impairments are other additional factors to suggest a limit value of 85 db (A) for workers in Pakistan. Noise induced health hazards can be reduced by improving work environment and promoting the hearing protection devices to reduce the adverse effects of the noise.

Good light at work place enables comfort and impact less stress on the eyes and nervous system. Poor light can cause visual as well as muscular problems including neck and back pain (IAPA, 2008). Poor lighting environment can cause a significant cost to business in the form of accidents, time off due to injuries, and absenteeism from work and decrease in staff efficiency and productivity (HSE, 2002). A comparison of visual problem with illumination showed highest

50% of workers with visual problems in industry 6 where they worked at an average illumination of 41.5 lux. Similar results were found in industry 3 where 25% of the workers had visual problems at an illumination of 42.3 lux. Collected data was small to make inferential statistical analysis and to generalise the results. A regression analysis was performed only for visual problem and light intensity to check the trend which showed that if the light intensity falls below 400 lux or increased above 800 lux the chances of developing visual problem increased as shown in Figure 2.

Another important factor that can influence the workers while performing their tasks is the thermal environment. Human performance can get affected by the thermal condition of hot and cold. Climate factors can affect all populations and regions but some groups and regions are more vulnerable to get affected such as outdoor workers are prone to these climatic factors because of their direct and longer exposure time. Climate change has exacerbated the stressful thermal environment for the workers belonging to construction, agriculture and other industries. Thermal stress includes impaired mental functions and lethargy which may increase the chances of risky behaviour by the worker (Miller & Bates, 2007). In Pakistan summer season normaly starts from May and extends up to October. Zahid and Rasul conducted a study on rise in summer heat index over Pakistan for the year 1961-2007 by using ambient temperature and relative humidity to calculate heat index (HI) according to Rothfusz equation as shown in Equation 3 (Zahid & Rasul, 2010).

Temperature varies markedly in Punjab from district to district and within the district from summer to winter season. The temperature may vary from -2 ºC to 50 ºC throughout the year. We recorded minimum temperature of 14.7 ºC under the measuring week in winter and highest temperature of 45.1 ºC in summer. Sometimes temperature also may exceed 50 ºC in the southern districts of the province. Statistics 2008 - 09 from Ministry of Labor and Manpower, Pakistan showed agriculture, manufacturers and construction occupations constitute 45%, 13 % and 7% of total occupational groups in Pakistan (Labour market information and analysis unit, 2008). These groups of workers are more vulnerable to heat stress because of their direct exposure to sun and long working hours inside room with poor ventilation. We recorded an average air velocity of 0.7 ± 0.3 m/s in summer. At some work places there was no proper ventilation and measured air velocity was 0.1 m/s with air temperature of 41 ºC which made evaporation, breathing and cooling mechanism difficult at these working environments. According to a study on iron workers in Punjab the workers were continuously exposed to high temperature. Heat illness and heat related disorders such as heat cramps, fatigues and asthmatic problems were very common among these workers (Malik & Cheema, 2010).

Workers data in our study reported moderate to high level of physical activity of 165 W/m^2 to 200 W/m^2 for which ISO 7243 recommended 50% work and 50% rest at WBGT of 30 ºC as shown in Figure 1. The latter was noted for summer season and a minimum of 4 hours rest has been recommended according to ISO 7243 for this WBGT level. It is difficult that metabolic activity level of workers remains the same throughout the working day and we also observed the variations in the physical activity level of the workers. Sometimes they perform activity at lower metabolic rate and had some time to relax their body. Based upon the fluctuation of physical activity and metabolic rate it is recommended for workers in our observed industries to have rest duration of at least 2 hours under a working day of 8 hours.

Variation in climate between the warm and cold season was immense but workers did not apply any adapting techniques according to the different season and they kept on working with same working hours, no protective clothing and no installation of air conditioning and heating system which could make them vulnerable to develop heat stress. Noweir, et al., 1996 conducted a similar study on cable industry workers in Jeddah to map the thermal limit value for workers. According to Noweir workers were exposed to high WBGT level of around 30 ºC with heavy work load. He suggested to modify the exposure time, lowering physical load, enhancing workers tolerance by acclimatization, taining of workers and provision of air cooled garments.

5. Conclusion

Working conditions in SMEs of Punjab-Pakistan needs improvement to protect workers from adverse effects of noise, light and temperature. ILO ergonomic check list can be an important tool to make assessment for work environment and to suggest improvements. Noise level should be limited to 85 dB (A) for these industries and lighting should be improved at work place to prevent workers from getting physical, psychological, visual and hearing problems. Small data size restrained us to make any concrete conclusion for light intensity level but the regression analysis trend showed that a range of 400 lux to 800 lux can be appropriate in these work settings. ISO 7243 can be utilized to define the heat exposure limits and to manage their needed work-rest schedule. Guidance from international standard of 7243 based on WBGT can be used to define work/rest ratio of the workers in order to maintain core body temperature of 38 C for the workers in summer. Minimum 2 hours rest in a working day of 8 hours during summer season is recommended to prevent workers from heat illness.

6. Limitations

There are some other factors including air pollution, water and sanitation conditions, vibration etc that can have adverse effect on the workers health but due to lack of funding and time we were not able to study these parameters. Young workers and healthy workers effect are the possible biased factors in this study that might influence the results based more towards healthy workers. Female workers are not included in this study because we did not find any female worker in these SMEs of Pakistan.

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Tables

Table 1: Health condition of SMEs workers of Pakistan in comparison to physical factors and ILO checklist

Industry #	Workers	Mean age	Musculoskeletal Problem	Respiratory Problem	Visual Problem	Hearing problem	Psychological problem	Cardiological Problem	Light	Noise	ILO Points		
	n	Years	%	%	%	%	%	%	lux	dB(A)	No	Yes	Priority
1	8	22.5	50	25	13	0	0	0	192.0	76.9	6	27	5
2	40	33.9	5	3	3	3	0	0	110.5	85.2	10	23	8
3	44	25.7	16	2	14	2	14	7	188.8	91.7	9	24	10
4	8	26.1	38	13	25	0	13	13	42.3	86.2	3	30	17
5	8	21.8	13	0	13	0	13	13	256.1	76.2	15	18	9
6	8	32.2	75	25	50	13	38	13	41.5	90.2	5	28	7
7	9	27.0	22	0	11	11	11	0	66.9	89.4	5	28	15
8	11	29.8	27	0	9	9	36	9	1063.3	73.1	15	18	10
Mean		28.6							245.2	83.6			
S.D		10.5							339.7	7.2			

Table 2: Climatic variable comparison for SMEs in Pakistan for winter and summer seasons

Industry #	Indoor Temperature Mean ± S.D	Indoor Relative Humidity Mean ± S.D	Outdoor Temperature Mean ± S.D	Outdoor Relative Humidity Mean ± S.D	WBGT Mean ± S.D
Winter season					
1	15.1 ± 1.4	40.9 ± 4.7	19.6 ± 2.4	31.6 ± 5.5	14.5 ± 1.3
2	14.7 ± 0.9	36.4 ± 4.7	14.7 ± 1.3	35.4 ± 5.4	13.7 ± 1.0
3	15.8 ± 1.6	37.0 ± 3.6	21.4 ± 3.9	27.0 ± 6.2	14.9 ± 1.3
4	18.2 ± 0.7	67.5 ± 1.0	23.0 ± 2.2	51.5 ± 5.7	17.9 ± 0.8
5	18.6 ± 2.0	41.2 ± 4.8	19.1 ± 3.9	34.8 ± 8.0	18.3 ± 1.4
6	14.9 ± 0.4	72.4 ± 1.3	15.3 ± 1.5	70.3 ± 4.2	14.8 ± 0.6
7	14.9 ± 0.8	71.5 ± 2.5	15.3 ± 1.5	70.3 ± 4.2	13.8 ± 0.8
8	21.0 ± 1.0	53.8 ± 4.6	22.4 ± 1.0	47.5 ± 4.5	20.4 ± 1.2
Summer season					
1	31.1 ± 0.4	67.6 ± 3.2	28.6 ± 1.2	75.0 ± 5.0	28.2 ± 0.1
2	31.7 ± 1.1	62.0 ± 5.7	33.5 ± 2.7	58.7 ± 8.9	28.2 ± 0.5
3	30.2 ± 0.8	65.2 ± 4.0	33.4 ± 2.7	58.6 ± 9.3	26.8 ± 0.3
4	31.4 ± 0.6	65.7 ± 2.2	33.4 ± 2.8	58.8 ± 9.0	27.9 ± 0.3
5	35.4 ± 0.9	51.4 ± 4.1	39.5 ± 1.3	43.5 ± 4.4	30.6 ± 0.4
6	37.7 ± 1.3	47.3 ± 2.8	38.9 ± 1.7	44.8 ± 3.6	31.6 ± 0.9
7	36.9 ± 0.9	55.4 ± 3.9	39.9 ± 1.0	45.7 ± 4.0	32.0 ± 0.8
8	41.4 ± 2.3	44.9 ± 3.4	44.1 ± 2.0	37.8 ± 3.8	34.1 ± 1.1
Mean comparison					
Winter	18.8 ± 3.4	46.0 ± 17	16.7 ± 2.3	52.6 ± 15.8	16.0 ± 2.5
Summer	34.5 ± 4.0	57.4 ± 8.9	36.4 ± 5.0	52.8 ± 12.1	29.9 ± 2.5

Figures

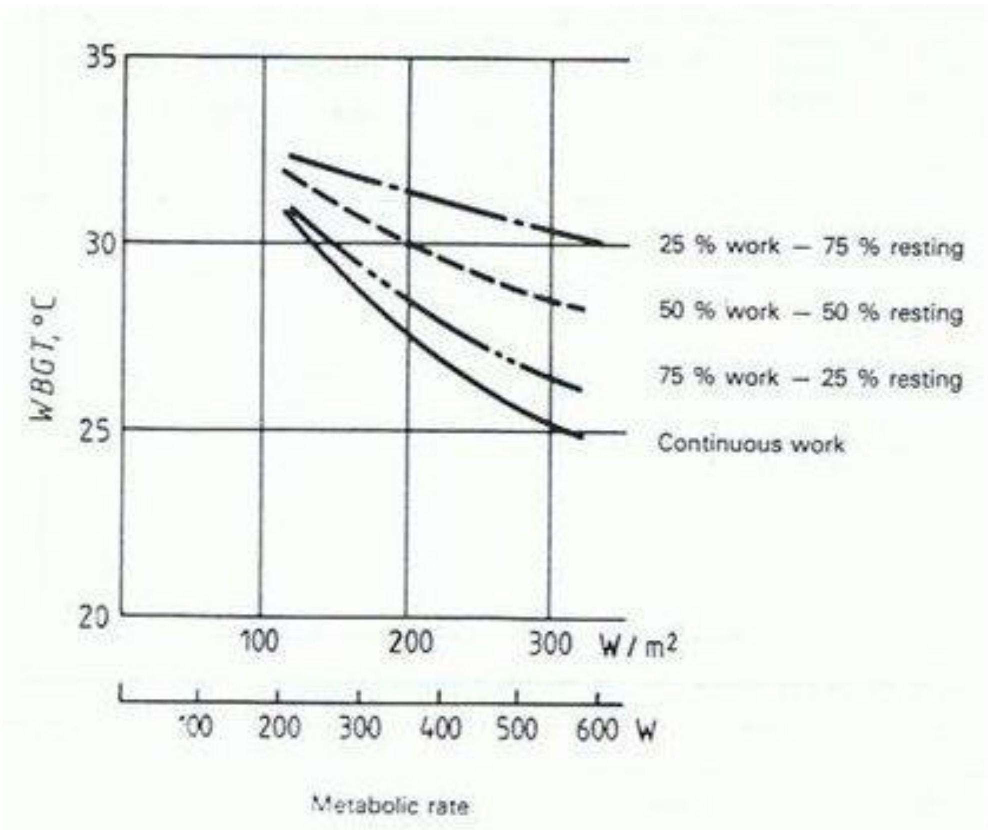

Figure 1: Reference Value of WBGT for various work/rest cycle

Source: ISO 7243 2nd edition 1989

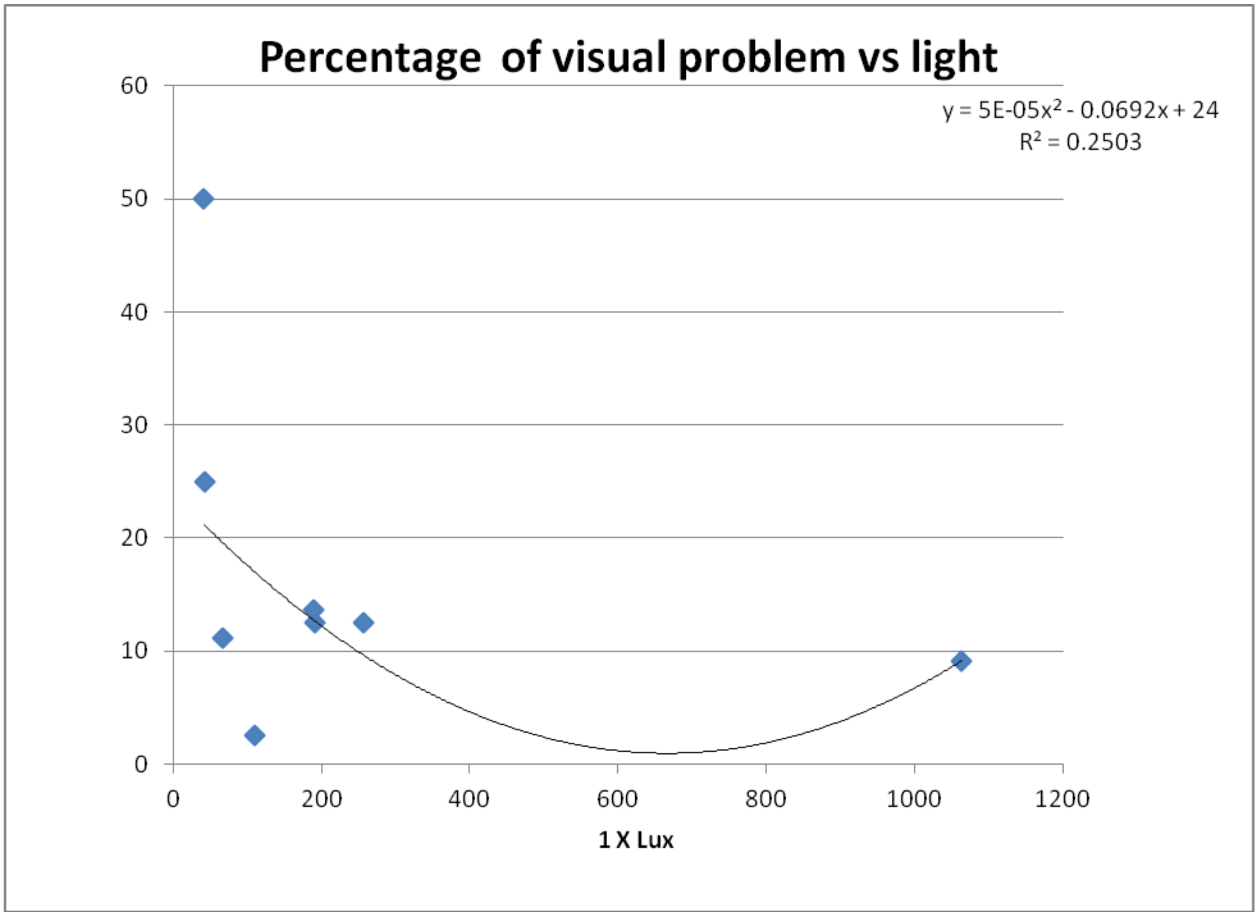

Figure 2: Regression analysis of illumination and visual problem

Appendix

Appendix 1: Quantitative Questionnaire

Subjective data

Factory code: _______________ Subject Code: ______________ Date:___________

Age: ________________ Gender: Male ☐ Female ☐

Smoking: Yes No ☐ ☐ Education: Illiterate Primary ☐ Literate ☐ ☐

Start of work: _____________mm/yr Number of working hours:___________/day

Type of work: Sitting ☐ Standing ☐ Walking ☐ Working Title: ______________

Have you got specific training: Yes ☐ No ☐ How long: _________________

Awareness about work safety: Yes ☐ No ☐

Level of exertion (Subjective): Mild ☐ Moderate ☐ High ☐

Metabolic level (ISO724): 1 ☐ 2 ☐ 3 ☐ 4 ☐ Sleeping Hours: ______/day

Salary: _____________PKR Number of resting hours_________________/day

---

Clinical History

Physical problem: Yes ☐ No ☐ If Yes: _______________________________

Respiratory problem: Yes ☐ No ☐ If Yes: _______________________________

Hearing problem: Yes ☐ No ☐ If Yes: _______________________________

Visual problem: Yes ☐ No ☐ If Yes: _______________________________

Psychological problem: Yes ☐ No ☐ If Yes: _______________________________

Cardio vascular problem: Yes ☐ No ☐ If Yes: _______________________________

Since when you have the problem: ____

Are you satisfied with job: Yes ☐ No ☐

Further comments:

____

Appendix 2: Selected checkpoints from ILO checklist.

Sr #	ILO Point	Check Point
		Physical Work
1	9	Use mechanical devices for lifting lowering and moving heavy materials.
2	38	Limit number of foot pedals and if used make them easy to operate.
3	51	Adjust working height for each worker at elbow level or slightly below.
4	56	Make sure that workers can stand naturally with weight on both feet and perform work close to and in front of the body.
5	57	Allow workers to alternate standing and sitting at work as much as possible.
6	58	Provide standing workers with chairs or stools for occasional sitting.
		Lighting
7	64	Increase the use of daylight and provide an outside view.
8	65	Use light colors for walls and ceilings when more light is needed.
9	66	Light up corridors staircases, ramps and other areas where people may walk or work.
10	67	light up the work area evenly to minimize changes in brightness.
11	68	Provide sufficient lighting for workers so that they can work efficiently and comfortably at all times.
12	69	Provide local lights for precision or inspection work.
13	70	Relocate light sources or provide shields to eliminate direct and indirect glare.
14	71	Choose an appropriate visual task background for tasks requiring close, continuous attention.
15	72	Clean windows and maintain light sources.
		Climate
16	73	Protect workers from excessive heat.
17	74	Protect workers from cold work environments.
18	75	Isolate or insulate sources of heat or cold.
19	76	Install effective local exhaust systems that allow efficient and safe work.
20	77	Increase the use of natural ventilation when needed to improve the indoor climate.
21	78	Use air-conditioning systems to provide an indoor climate conducive to the health and comfort of people.
22	79	Improve and maintain ventilation systems to ensure good workplace air quality.
		Noise
23	85	Isolate or cover noisy machines or parts of machines.
24	86	Maintain tools and machines regularly in order to reduce noise.
25	87	Make sure that noise does not interfere with verbal communication and auditory signals.
		Protection
26	97	Provide rest facilities for recovery from fatigue
27	98	Provide easy access to first-aid equipment and primary health-care facilities at the workplace.
28	101	Provide personal protective equipment that gives adequate protection.
29	102	Ensure regular use of personal protective equipment by proper instructions, adaptation trials and training.
30	103	Make sure that everyone uses personal protective equipment where it is needed.
31	104	Make sure that personal protective equipment is acceptable to the workers and that it is cleaned and maintained.
32	121	Provide short, frequent pauses during continuous precision or computer work to increase productivity and reduce fatigue.
33	122	Provide opportunities for physical exercise for workers.

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