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Faculty of Graduate Studies

The Effect of Light Intensity on Employees' Health in Pharmaceutical Companies

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This Thesis is Submitted in Partial Fulfillment of Requirements for the Degree of Master of Physics, Faculty of Graduate Studies, An-Najah National University Nablus, Palestine.

2014

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Dedication

To the soul of my father

Acknowledgements

I am very pleased to express my deep gratitude to my supervisor Dr. Issam Rashid and co-supervisor Dr. Mohammed Abu-Jafar for their supervision, guidance and insightful suggestions.

Special thanks are addressed to the managers of the Birzeit and Dar Alshifa companies, and special thanks for the employees whom contributed considerably to the completion of this research.

In addition, I would like to thank my family members for their support and permanent encouragement that helps me to fulfill my study.

الإقرار

أنا الموقع ادناه مقدم الرسالة التي تحمل عنوان:

The Effect of Light Intensity on Employees' Health in Pharmaceutical Companies

أقر بان ما اشتملت عليه هذه الرسالة، إنما هو نتاج جهدي الخاص، باستثناء ما تمت الإشارة اليه حيثما ورد، وان هذه الرسالة ككل، او اي جزء منها لم يقدم من قبل لنيل اية درجة علمية لدى اي مؤسسة تعليمية او بحثية اخرى.

Declaration

The work provided in this thesis, unless otherwise referenced, is the researcher's own work, and has not been submitted elsewhere for any other degree or qualification.

Student's name: **اسم الطالب:**

Signature: **التوقيع:**

Date: **التاريخ:**

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List of Abbreviations

a	After
a.m.	After Midnight
Å	Angstrom
A1	The first value of the measured parameter after light exposure.
A2	The second value of the measured parameter after light exposure.
b	Before
B1	The first value of the measured parameter before light exposure.
B2	The second value of the measured parameter after light exposure.
BZPB	Birzeit Pharmaceutical company (Birzeit branch)
BZPR	Birzeit Pharmaceutical company (Ramallah branch)
DA	Dar AlShifa'a Pharmaceutical company
dB	Decibel
DBP	Diastolic Blood Pressure
Fig.	Figure
HPR	Heart Pulse Rate
Lux	Unit of Illumination
Max.	Maximum
Min.	Minimum
m/s	Meter Per Second
NEMA.	National Emergency Medicine Association
nm	Nanometer
p.m.	Before Midnight
P – value	Probability
SBP	Systolic Blood Pressure
S.D	Standard Deviation
SI	International System
SPO_2%	Blood Oxygen Saturation
T	Tympanic Temperature
WHO	World Health Organization

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Abstract

In this study we have measured the effect of light intensity levels on the systolic and diastolic blood pressure, blood oxygen saturation, heart pulse rate and tympanic temperature of the employees of three pharmaceutical companies in Ramallah and Al-Bireh district. The employees were chosen to represent the population of the study. The companies were: Birzeit pharmaceutical company-Ramallah branch (BZPR), Dar Alshifa pharmaceutical company (DA), and Birzeit pharmaceutical company-Birzeit branch (BZPB). The sample of the study consisted of 219 employees distributed over the three companies. The parameters were measured before and after the employees work day. The results showed that there is a relation between light intensity levels and all the health parameters.

The results of measurements of systolic and diastolic blood pressure show that they are increasing with increasing light intensity levels. The values of Sig P-values were found to be 0.000 and 0.023 for systolic and diastolic blood pressure respectively, while the results of SPO_2% show that they decrease with increasing light intensity levels, with Sig P-value was

calculated to be 0.000. The tympanic temperature increases when light intensity level increases, (Sig P-value = 0.002). However all changes were in normal range of the recommended standards.

Chapter One

Introduction

1.1 Theory of Light

Light is part of the electromagnetic spectrum Radiation, which ranges from radio waves to gamma rays.

1.1.1 Electromagnetic Radiation and Light

Electromagnetic radiation (EMR) is a form of energy emitted and absorbed by charged particles which exhibits wave-like behavior as it travels through space. EMR has both electric and magnetic field components, which stand in a fixed ratio of intensity to each other, and which oscillate in phase perpendicular to each other and perpendicular to the direction of energy and wave propagation. In a vacuum, electromagnetic radiation propagates at a characteristic speed, the speed of light (Paul T., 2004).

The behavior of EMR depends on its wavelength. Higher frequencies have shorter wavelengths, and lower frequencies have longer wavelengths. When EMR interacts with single atoms and molecules, its behavior depends on the amount of energy per quantum it carries.

EMR in the visible light region consists of quanta (called photons) that are at the lower end of the energies that are capable of causing electronic excitation within molecules, which lead to changes in the bonding or chemistry of the molecule. At the lower end of the visible light spectrum, EMR becomes invisible to humans (infrared) because its photons no longer have enough individual energy to cause a lasting molecular change (a change in conformation) in the visual molecule retinal in the human retina, which change triggers the sensation of vision (Buser P., 1992).

EMR is classified by wavelength into radio, microwave, infrared, the visible region that we perceive as light, ultraviolet, X-rays and gamma rays (Table 1.1).

Table (1.1): Approximate wavelengths, frequencies, and energies for selected regions of the electromagnetic spectrum, (NASA's Imagine the universe, 2004)

Spectrum of Electromagnetic Radiation			
Region	Wavelength(Å)	Frequency (Hz)	Energy (eV)
Radio	$> 10^9$	$< 3 \times 10^9$	$< 10^{-5}$
Microwave	$10^6 - 10^9$	$3 \times 10^9 - 3 \times 10^{12}$	10^{-5} - 0.01
Infrared	$7\times10^3 - 10^6$	$3 \times 10^{12} - 4.3 \times 10^{14}$	0.01 - 2
Visible	$4\times10^3 - 7\times10^3$	$4.3 \times 10^{14} - 7.5 \times 10^{14}$	2 - 3
Ultraviolet	$10 - 4\times10^3$	$7.5 \times 10^{14} - 3 \times 10^{17}$	$3 - 10^3$
X-Rays	10 - 0.1	$3 \times 10^{17} - 3 \times 10^{19}$	$10^3 - 10^5$
Gamma Rays	< 0.1	$> 3 \times 10^{19}$	$> 10^5$

Visible light (commonly referred to simply as light is electromagnetic radiation that is visible to the human eye, and is responsible for the sense of sight (CIE, 1987). Visible light has a wavelength in the range of about (380 – 740) nm, between the invisible infrared, with longer wavelengths and the invisible ultraviolet, with shorter wavelengths, Primary properties of visible light are intensity, propagation direction, frequency or wavelength spectrum, and polarization, while its speed in a vacuum, 299,792,458 meters per second, is one of the fundamental constants of nature. Visible light, as with all types of electromagnetic radiation (EMR), is experimentally found to always move at this speed in vacuum (Paul T., 2004).

The common sources of light are thermal, a body at a given temperature emits a characteristic spectrum of radiation. The most important source of light is the sun, it emits from its chromosphere a radiation of 6000 Kelvin peaks in the visible region of the electromagnetic spectra in wavelength units, the radiation of the sunlight energy that reached the earth is 44% visible light (Hong T., 2009).

From many artificial sources of light, the fluorescent lamp the high efficiency (80% - 90%) and is the source that is commonly used for lighting (Stephen D., 2002).

The intensity of light or other linear waves radiating from a point source (energy per unit of area perpendicular to the source) is inversely proportional to the square of the distance from the source. In general the intensity (or power per unit area in the direction of propagation), of a spherical wave front varies inversely with the square of the distance from the source, assuming there are no losses caused by absorption or scattering.

For non-isotropic such as parabolic antennas, headlights, and lasers, the effective origin is located far behind the beam aperture. If you are close to the origin, you don't have to go far to double the radius, so the signal drops quickly. When you are far from the origin and still have a strong new signal, like with a laser, you have to travel very far to double the radius and reduce the signal. This means you have a stronger signal or have antenna gain in the direction of the narrow beam relative to a wide beam in all directions of an isotropic antenna. . So we can use the inverse square law to calculate the indirect ionizing radiation with increasing distance from appoint source. So this law is important in diagnostic radiography and radiotherapy treatment planning. Finally we can say that this proportionality does not hold in practical situations unless source dimensions are much smaller than the distance, (Gal *et al*., 2005)

There are two types of units that used to measure light parameters, the first type is called radiometry which measures the light power at all wavelengths, and the other type is called photometry which measures the light weighted with respect to a standardized model of human brightness perception (Bass M., 1995).

1.1.2 Light absorption

Light exerts physical pressure on objects in its path, a phenomenon which can be deduced by Maxwell's equations, but can be more easily explained by the particle nature of light: photons strike and transfer their momentum. Light pressure is equal to the power of the light beam divided by the speed of light(c). Due to the magnitude of c, the effect of light pressure is negligible for everyday objects (Tang H., 2009).

The amount of radiation absorbed by a sample depends on the chemical identity of the sample, its thickness, and the wavelength of the radiation of the source.

Beer observed that for solutions, the amount of radiation absorbed by a body is proportional to the concentration of dissolved substance which is given as Beer law (Harrison *et al*., 2011):

$$I = I_o exp\,(-\alpha xc)$$

Where I = the intensity of the radiation which crossed a thickness of x of the absorbing medium (J/m^2s), I_o = the intensity of the incident radiation (J/m^2s), α = absorption coefficient (litter $mole^{-1}$ cm^{-1}), x = the length of the radiation path (cm), and c = the concentration of the absorbing material (moles $litter^{-1}$).

1.2 Lighting and Health

Lighting has both a visual and non-visual (such as the release and production of hormones) influence on humans according to several studies, (Aries M., 2005). For many decades researchers studied the effect of light intensity on human health. Humans are affected both psychologically and physiologically by the different spectra provided by the various types of light. In many places, a high intensity light is needed to serve special requirements, in these places light may be harmful for human health.

Many world organizations concerned in the problem of lighting. They put forward laws and determinants for recommended lighting conditions, such as World Health Organization (WHO) and Illuminating Engineering Society of North America (IESNA). The following Table shows the values for light intensity that meets visual demands for human in different situations according to the engineering toolbox (the engineering toolbox, 2013).

Table (1.2): Values for light intensity meet visual demands for human in different situations (the engineering toolbox, 2013)

Activity	**Illumination intensity (Lux)**
Warehouse, Homes, Theaters, Archives	150
Easy Office Work, Classes	248
Normal Office Work, PC work, Study library, Groceries, Show rooms, laboratories	500
Supermarkets, Mechanical Workshops, Office Landscapes	750
Normal Drawing Work, Detailed Mechanical Workshops, Operation Theatres	1000
Detailed Drawing, very Detailed Mechanical Works	1500 – 2000

1.3 Previous Studies

The exposure of human to light has been tested by several researchers. Wurtman studied the influences of light on human health and suggested that exposure to artificial light may have harmful effects. He tested the urine samples for six persons and six rats for a period of 8 hours exposure to light, he also concluded that the effects of light on mammalian tissue are either direct or indirect, depending on whether the immediate cause is a photochemical reaction within the tissue or a neural or neuroendocrine signal generated by a photoreceptor cell (Wurtman R., 1975).

The photic simulation was used to study the effects of alternating and continuous bright light and dim light conditions on body temperature. It was found that for the nighttime alternating condition, body temperature decreased under dim light but either increased or maintained under bright light. For the continuous light condition, body temperature dropped sharply across the night under dim light but dropped only slightly under bright light (Badia *et al*., 1991).

In their review, Edward and others concluded that with properly installed and maintained day lighting systems in buildings, natural light has proved to be beneficial for the health, productivity, and safety of building occupants. Natural light helps maintain good health and can cure some medical ailments. The pleasant environment created by natural light decreases stress levels for office workers (Edwards *et al*., 2002).

Boyce and his group studied the impact of light in buildings on human health, by two experiments concerning the effects of variations in lighting quality on office worker performance, health, and well-being. Experiment 1 had four experimental conditions: a regular array of fully direct recessed parabolic luminaires; direct/indirect luminaires with no control; direct/indirect luminaires with a switchable desk lamp; and, workstation-specific direct/indirect luminaires with control over the direct portion. Experiment 2 contrasted two conditions with no individual lighting control: a regular array of recessed prismatic lensed luminaires, and suspended direct/indirect luminaires. Participants considered the direct/indirect systems to be more comfortable than the direct-only systems, with a further increase in comfort associated with individual control in Experiment 1. They concluded that exposure to light can have both positive and negative impacts on human health, these impacts can become evident soon after exposure or only after many years (Boyce *et al*., 2003). If the human body exposure to dim light, a hormone called Melatonin is produced by pineal gland in the brain, reduces blood pressure and body temperature (Pandi *et al*., 2006).

Harrison and his group studied the effect of light and architecture of day light sleep, they placed 17 young adults under four different lighting conditions during their nap: physiological darkness (~0 lux), moonlight (~1 lux), typical indoor lighting (~80 lux), and indirect outdoor light (~6400 lux). They found that all subjects were able to sleep in all lighting conditions with no differences in sleep quality or architecture (Harrison *et al.,* 2011).

It was suggested that rotating nightshifts can disrupt circadian rhythms and induce health disorders. They found also that spectral modulation may provide an effective method of regulating the effects of light on physiological processes (Rahman *et al.,* 2011). Uger suggested that short wavelength visible light exposures may be more efficient than traditional high intensity white light exposures for treatment of circadian rhythm sleep disorders (Uger *et al.*, 2013).

In 2001 Peng and others showed that pulse rate increased and the blood oxygen saturation decreased as the intensity of light increases. The study shows: (1) Light intensity had a significant statistical relationship with the premature infants' physiological parameters ($p = 0.00$). (2) The heart rate and respiration rate increased and the blood oxygen saturation decreased as the intensity of light went up (Peng *et al*., 2001).

The exposure to light at night increases the sex hormone levels during women pregnancy (Wada *et al.,* 2013). A paper published by Saito and his group showed an increase in muscle sympathetic nerve activity and heart rate in response to bright light (Saito *et al.*, 1996).

In 1999, Gilbert and his group found a reduction of the heart rate of healthy young males after the administration of exogenous melatonin during the afternoon (Gilbert *et al.,* 1999*)*. In their study, Tsunoda and others observed an increase in the low frequency-to-high frequency ratio of the heart rate variability after bright light exposure and after exposure to complete darkness (Tsunoda *et al.,* 2001*)*. Besides heart rate variability, cortisol also shows a clear circadian rhythm with a peak around awakening (Kudielka *et al.,* 2003). The circadian rhythm in cortisol is largely under the control of the circadian pacemaker in the suprachiasmatic nucleus (Buijs *et al*., 1999). Abu Ras studied the effect of light intensity on arterial blood pressure (systolic and diastolic), heart pulse rate, oxygen saturation in blood and tympanic temperature of 237 children aged (5 - 6) years in Jenin city (Abu Ras H., 2012), she found a strong positive correlation (Pearson Correlation Coefficient) between light intensity level and all of the arterial blood pressure (systolic and diastolic), heart pulse rate, blood oxygen saturation and tympanic temperature. For example, at light intensity levels more than the normal (1320, 1400 and 1500 lux) the average Pearson Correlation Coefficient is (R = 0.593 for systolic, R = 0.561 for diastolic, R = 0.675 for heart pulse rate, R = 0.722 for oxygen saturation and R = 0.744 for tympanic temperature).

The effect of light intensity on blood oxygen saturation, heart pulse rate, arterial blood pressure (systolic, diastolic), and tympanic temperature of 207 nurses was studied in their shift work. The study showed that the health effects of light intensity depend on the light intensity itself, more specifically, nurses exposed to light intensity 1700 Lux, have a significant shift of the measured mean values (blood oxygen saturation, heart pulse rate, arterial blood pressure (systolic and diastolic), and tympanic temperature), more than nurses exposed to light intensity less than 500 Lux. It was also found that blood oxygen saturation has Pearson's Coefficient R = 0.980 and probability P = 0.020, whereas heart pulse rate has R = 0.966 and probability P = 0.034, while systolic blood pressure has R = 0.985 and P = 0.015. In addition, diastolic blood pressure has R = 0.989 and P = 0.011, and the values for temperature are R = 0.990 and P = 0.010 (Fareed *et al.*, 2013).

1.4 Research Objectives

There is a lack of research concerning the effect of light exposure on the human body in Palestine. Based on a visit to three pharmaceutical companies in Ramallah area, it was found that the light intensity in some places inside the companies may approach 2000 lux. Some of the employees are in direct exposure to this intense light for more than eight hours a day. A study should be done to investigate the effects of this long time exposure of light on their health. This problem is classified to be severe concern (2000 Lux) and a study must be done.

The primary purpose of this study is to identify the effects of light intensity on systolic and diastolic blood pressure, heart pulse rate, blood oxygen saturation and tympanic temperature of the employees of pharmaceutical companies in Ramallah region. The companies are: Birzeit Pharmaceutical Company- Ramallah branch, Dar AlShifa Pharmaceutical Company, Birzeit Pharmaceutical Company- Birzeit branch. The study was done in July, 2013.

The objectives of the study are:

1- Measuring the light intensity in three pharmaceutical companies in Ramallah region and compare it with standard values.

2- Studying the effect of light intensity on systolic and diastolic blood pressure, heart pulse rate, tympanic temperature, and blood oxygen saturation of the employees of these companies.

Chapter Two

Methodology

2.1 The Population of the Study

The medical reports of the employees included in company's records were revised in order to make sure that our sample doesn't have any health problems. The ranges of ages extend from 17 to 62 years. The overall numbers of checked employees were 219 distributed according to their gender and company according to Table 2.1.

Table (2.1): Distribution of employees according to gender in the companies

Company	Male	Female
Birzeit Pharmaceutical-Ramallah	46	37
Dar AlShifa'a Pharmaceutical	44	41
Birzeit Pharmaceutical –Birzeit	22	29

The light intensity level inside these companies was measured and found to extend from 248 to 2200 Lux, and then it was classified into 4 categories: from 248 to 500, from 600 to 800, from 1000 to 1500, and from 1800 to 2200 Lux.

All health parameters were measured half an hour before the employees started their work. These parameters were also measured after 8 hours from starting time under different light intensity levels. Each test was done two times for each parameter and then the average was taken.

The size of the sample was chosen according to Cochran formula as follows: (Cochran W., 1977).

$$n_0 = \frac{z^2 pq}{e^2}$$

Where n_0 is the sample size, z is the value to which the confidence level corresponds, p is estimated proportion of an attribute that is present in the population, q = 1- p and e is the desired level of precision (acceptable margin of error for proportion). The value of z is 1.96, p = 0.9 and so q = (1- p) = 0.1, the acceptable margin of error (e) was taken to be 0.05.

According to this value,$n_0$is calculated as follows:

$$n_0 = \frac{(1.96)^2 \times 0.9 \times 0.1}{(0.05)^2} = 138.296$$

The corrected sample size is:

$$n = \frac{n_0}{1 + \frac{(n_0 - 1)}{N}}$$

Where N: is the population size for each company.

n: for each company is

Birzeit Pharmaceutical Company-Ramallah branch:

$$n = \frac{139}{1 + \frac{(139-1)}{150}} \approx 73$$

Dar AlShifa`S Pharmaceutical Company:

$$n = \frac{139}{1 + \frac{(139-1)}{250}} \approx 90$$

Birzeit Pharmaceutical Company-Birzeit branch:

$$n = \frac{139}{1 + \frac{(139-1)}{60}} \approx 42$$

The range of the noise pressure was measured to be (40.2 - 55.3) dB with average (46.8) dB. This value of noise pressure level is considered to be quite (acceptable).

2.2 Experimental Apparatus

Hioki 3423 Lux Hitester Digital illumination meter:

This device is to measure the light intensity. The instrument measures a broad range of luminosities, from the low light provided by induction lighting up to a maximum intensity of 199,900 Lux.

Lux meter depend on photo cell to hold the light then it converts it into an electrical current, and by measuring this current allows the device to calculate the lux value of the light it hold. This general principle works for all light meters, including digital camera, a light- sensitive photocell regulates the amount of electricity flowing in the metering system, so when the intensity of the light reflected from the subject changes the amount of electricity flowing through the photocells circuits, changes this using the auto exposure system to calculate and set the shutter speed and aperture, (Heinemann B., 1997).

Automatic Blood Pressure Monitor:

This apparatus was used to measure the arterial Blood pressure (systolic, diastolic) and pulse rate.

Measuring range is: (30 - 280) mmHg.

Accuracy ± 2% and ± 2% for reading heart pulse rate.

Pulse Oximeter LM-800 (Finger Oximeter):

This apparatus was used to measure the blood oxygen saturation with accuracy of ±1%. A source of light originates from the probe at two wavelengths (65nm and 805nm). The pulse oximeter consists of a probe attached to the patient's finger, the light is partly absorbed by hemoglobin, by amounts which differ depending on whether it is saturated or DE saturated with oxygen, saturated hemoglobin absorbs more infrared light and allows more red lights to pass through, DE saturated (or reduced) hemoglobin absorbs more red light and allows more infrared light to pass through. By calculating the absorption at the two wavelengths the processor can compute the proportion of hemoglobin which is oxygenated, (Jan *et al*., 1995).

The GT-302/GT-302-1 Ear Thermometer:

This instrument is used to measure human body temperature through the tympanic temperature of the ear. The display temperature range is 32.0 to 42.9 °C with accuracy range ± 0.1°C. The device measures the infrared energy emitted from the patient's eardrum in a calibrated length of time, the

infrared energy falls on a thin pyroelectric crystal which develops a charge proportional to that collected energy. Discharging the crystal sends a current pulse through filters and conversion circuits which compare the signal to tabulated data on temperature and calculate a body temperature for the display (Wenbin *et al*., 2010).

2.3 Recommended Standards of Health Parameters

Normal adult blood pressure is defined as a blood pressure of 120 mmHg when the heart beats (systolic) and a blood pressure of 80 mmHg when the heart relaxes (diastolic). When systolic blood pressure is equal to or above 140 mmHg and a diastolic blood pressure equal to or above 90 mmHg the blood pressure is considered to be raised or high. Normal blood oxygen saturation levels fall between 95 and 99 percent. Normal heart rate range anywhere in the range of (60 – 90) beat/min Tympanic temperature is 36.8° ± 0.5°C for normal humans as shown in Table (2.2).

Table (2.2): The normal range levels of SBP, DBP, SPO_2%, HBR and T for adults

Category	Normal Range
DBP	60 - 89 (mmHg) [a]
SBP	90 - 140 (mmHg) [b]
SPO_2%	95 – 99 [c]
HBR	60 - 90 (beat/min) [d]
T	34.7 - 35.3 (^{o}C) [f]

a: WHO, (2014).

b: WHO, (2014).

c: Longo *et at*., (2011).

d: NEMA, (2013).

f: Longo *et at*., (2011).

2.4 Analysis Technique

The collected data will be analyzed by using EXEL and SPSS. Data were classified according to company, gender, and employees' age. The relationships between the health parameters versus light intensity levels are plotted according to these categories.

Chapter Three

Results

3.1 Population

The population of this study was 219 employees, distributed in three pharmaceutical companies in Ramallah area. The employees work 8 hours a day. The sample is distributed according to employee gender as in Table 3.1.

Table (3.1): The gender percentage of the sample

Gender	Number	percentage
Male	112	51.1%
Female	107	48.9%
Total	219	100%

The distribution of the sample over companies is ginen in Table 3.2.

Table (3.2): The gender frequency of the sample according to the selected companies

Company	Gender		Total
	Male	Female	
Birzeit Pharmaceutical-Ramallah	46	37	83
Dar AlShifa'a pharmaceutical	44	41	85
Birzeit Pharmaceutical –Birzeit	22	29	51
Total	112	107	219

3.2 Noise Pressure Level

The noise pressure level was measured at different locations of the employees in each company, these measurements were done in order to make sure that the noise does not affect the measurements. The locations of high noise where there are machines were excluded from the study. The results of noise measurements are tabulated in Table 3.3.

Table (3.3): Sound pressure levels in the three selected companies

Noise Pressure Level (dB)				
Company	Minimum	Maximum	Mean	Std. Deviation
Birzeit Pharmaceutical -Ramallah	40.2	55.2	47.7	4.8
Dar AlShifa'a pharmaceutical	41.1	55.2	45.7	4.1
Birzeit Pharmaceutical-Birzeit	41.1	55.3	47.2	4.3

These values of noise pressure level are quite (acceptable) and do not affect our results.

3.3 Light Intensity Level

The light intensity was measured in the places where the employees are working. The light intensity level did not change during the work day. Employees work under different light intensity levels, the light intensity level extended from 248 to 2200 Lux and they have been classified into four main ranges:(248 - 500 Lux), (600 - 800 Lux), high (1000 - 1500 Lux), and very high (1800 - 2200 Lux) as in Table 3.4.

Table (3.4): Light intensity levels according to the selected companies

Company	(248 - 500)Lux			(600 - 800) Lux		
	Min	Max	Average	Min	Max	Average
Birzeit-Ramallah	248	407	316.6	630	790	690.6
Dar Al-Shifaa	363	439	407.3	630	790	708.1
Birzeit-Birzeit	367	414	390.5	639	754	689.5
Company	High Intensity (1000 - 1500) Lux			Very High Intensity (1800 - 2200) Lux		
	Min	Max	Average	Min	Max	Average
Birzeit-Ramallah	1074	1487	1324.1	1877	2180	2016.8
Dar Al-Shifaa	1347	1487	1392.3	1989	2189	2077.0
Birzeit-Birzeit	1087	1404	1267.6	1894	2200	2057.0

Table 3.4 shows the distribution of light intensity ranges in BZPR, DA, and BZPB companies. The minimum value of intensity was measured in BZPR (248 Lux) while the maximum value was in BZPB (2200Lux). The averages of intensities for each intensity range are closed to each other's for different companies.

3.4 Results of Measurements

Data were collected in July, 2013. Measurements of systolic and diastolic blood pressure, blood oxygen saturation, heart pulse rate, and tympanic temperature were taken two times at 7:30 - 8:00 a.m., and then the same measurements for the same employees were taken again after the work day at 4:00 - 4:30 p.m.

3.4.1 Blood Pressure

The systolic and diastolic blood pressures of the employees sample were measured at 7:30 - 8:00 a.m. at 4:00 - 4:30 p.m. Two measurements were taken before and after work, then the average was taken.

a. Systolic Blood Pressure (SBP)

The average value and standard deviation of the measured SBP of all employees in the three companies are shown in Table 3.5.

Table (3.5): The average values and standard deviations of the measured SBP for the employees in the selected companies

Company Name	Intensity Level Range (Lux)		SBP (before) (mmHg)	SBP (after) (mmHg)
Birzeit-Ramallah	Low (248 - 500)	Mean	115.8	116.9
		S.D	17.2	18.5
	Normal (600 - 800)	Mean	124	125.4
		S.D	11.5	12.5
	High (1000 - 1500)	Mean	118.8	122.5
		S.D	7.8	9.2
	very High (1800 - 2200)	Mean	131.4	138.3
		S.D	21.2	20.6
Dar Al-Shifaa	Low (248 - 500)	Mean	117.5	118.5
		S.D	9.3	11
	Normal (600 - 800)	Mean	122.4	124.3
		S.D	10.91	12.8
	High (1000 - 1500)	Mean	121.8	126.9
		S.D	18.4	13.8
	very High (1800 - 2200)	Mean	129.4	137.5
		S.D	32.8	33
Birzeit-Birzeit	Low (248 - 500)	Mean	124.1	125.2
		S.D	13.8	12.6
	Normal (600 - 800)	Mean	123.1	124.9
		S.D	10.9	12.7
	High (1000 - 1500)	Mean	122.7	127
		S.D	10.3	13.3
	very High (1800 - 2200)	Mean	127.5	132.4
		S.D	14.3	14.7

Table (3.5) shows that the average values of SPB increase at all intensity ranges for all employees in all companies.

The average of SBP for high intensity range changes from (131.4 to 138.3) mmHg for Birzeit Pharmaceutical (Ramallah branch), (129.4 to 137.5) mmHg for Dar Al-Shifa'a whereas (127.5 to 132.4) mmHg for Birzeit Pharmaceutical (Birzeit branch).

The following Figs. (3.1 - 3.3) show the percentage of changes in SBP for all employees in BZPR, DA, and BZPB. Where Δ(SBP) represents the change of systolic blood pressure before and after exposure to light.

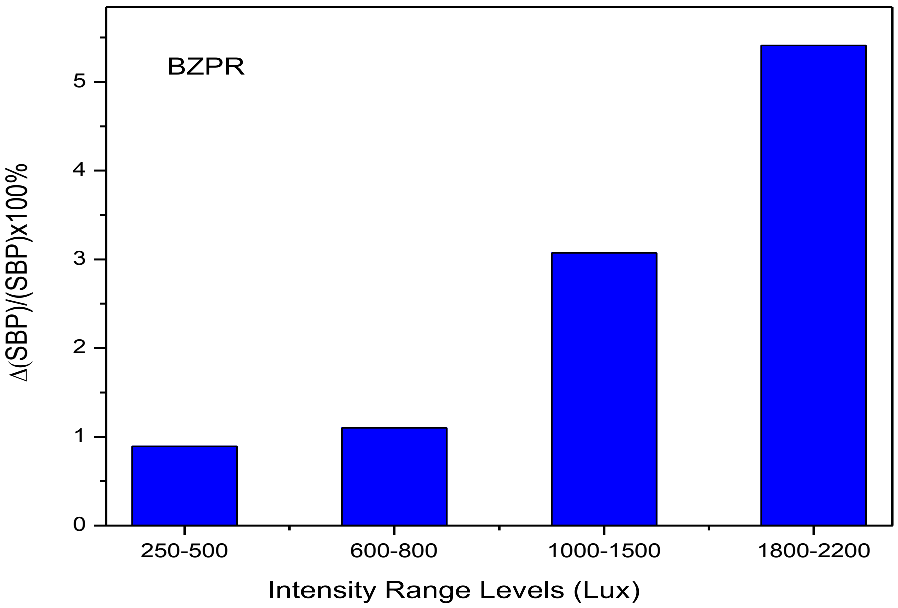

Fig. (3.1): Mean percentage change in SBP for all employees in BZPR versus light intensity range levels (Sig P-value = 0.001)

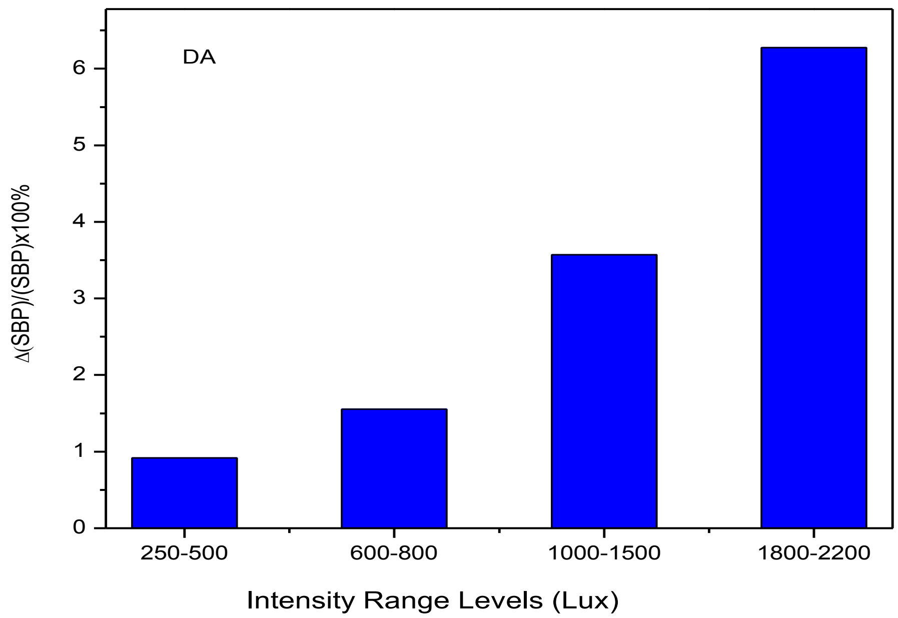

Fig. (3.2): Mean percentage change in SBP for all employees in DA versus light intensity range levels (Sig P-value = 0.000)

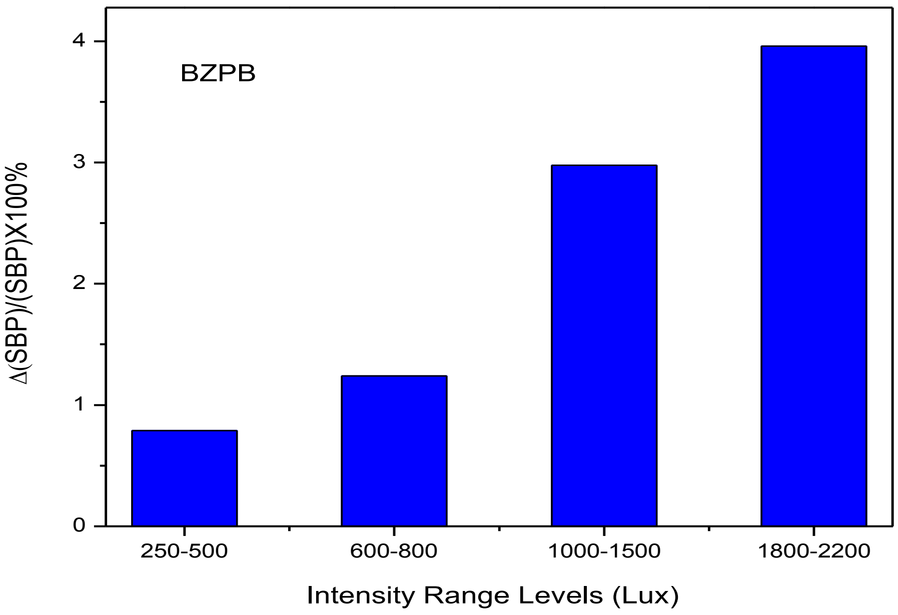

Fig. (3.3): Mean percentage change in SBP for all employees in BZPB versus light intensity range levels (Sig P-value = 0.022)

One can observe from Fig. 3.1 that the change in SBP in BZBR is small when the light intensity is (248 - 500) Lux. It increases as the light intensity increases, especially for very high intensity range (1800 – 2200) Lux. The same behavior exists in the other two companies Figs. (3.2 - 3.3). In Fig. 3.2 the percentage change is very small (less than 0.01) in the (248-500) Lux range. It increases slightly in (600 - 800) Lux range, but the change is noticeable in the high and very high intensity ranges. The percentage change of SBP of Dar Alshifa employees is the greatest of the three companies. The percentage change of SBP of Dar Alshifa employees is in general less than that of BZPR and BZPB employees, for instance the percentage change of SBP in the very high intensity range is around 4%, while it is 5% for BZPR and 6% for DA.

b. Diastolic Blood Pressure (DBP)

The average values of DBP of the employees in the three companies before and after light exposure are displayed in Table 3.6. DBP was measured for the same sample. The exposure to light in the three companies raises the DBP of the employees for all intensity ranges. The change in DBP is observed even when the light intensity is low (500 Lux).

Table (3.6): The average values and standard deviations of the measured DBP for the employees in the selected companies

Company Name	Intensity Level Range (Lux)		DBP (before) (mmHg)	DBP (after) (mmHg)
Birzeit-Ramallah	Low (248 - 500)	Mea	73.4	73.7
		S.D	9.4	10.1
	Normal (600 - 800)	Mea	74.5	75.1
		S.D	8.9	7.8
	High (1000 - 1500)	Mea	75.3	77.3
		S.D	6.1	6.6
	very High (1800 - 2200)	Mea	74.2	76.9
		S.D	5.3	5.3
Dar Al-Shifaa	Low (248 - 500)	Mea	73.9	74.2
		S.D	10.4	11.0
	Normal (600 - 800)	Mea	75.7	77.0
		S.D	8.8	8.6
	High (1000 - 1500)	Mea	70.2	73.4
		S.D	8.4	9.0
	very High (1800 - 2200)	Mea	76.4	78.1
		S.D	4.9	5.2
Birzeit-Birzeit	Low (248 - 500)	Mea	77.9	78.3
		S.D	11.8	10.3
	Normal (600 - 800)	Mea	73.3	73.7
		S.D	9.7	9.2
	High (1000 - 1500)	Mea	75.7	77.8
		S.D	8.7	8.4
	very High (1800 - 2200)	Mea	77.7	79.4
		S.D	4.7	5.7

The mean percentage change in DBP is plotted against light intensity range. The results are shown in Figs. (3.4 - 3.6) for each company.

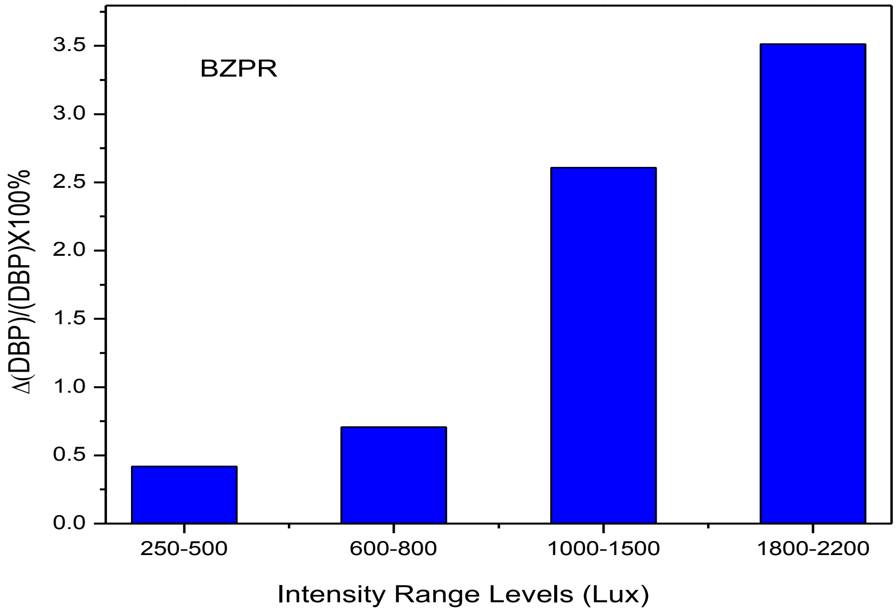

Fig. (3.4): Mean percentage change of DBP for all employees in BZPR versus light intensity range levels (Sig P-value = 0.002)

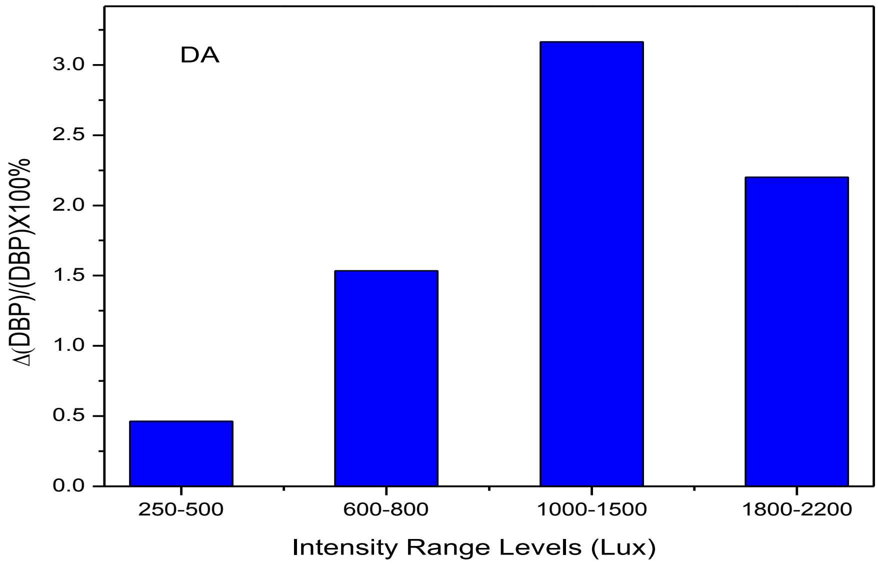

Fig. (3.5): Mean percentage change of DBP for all employees in DA versus light intensity range levels (Sig P-value = 0.021)

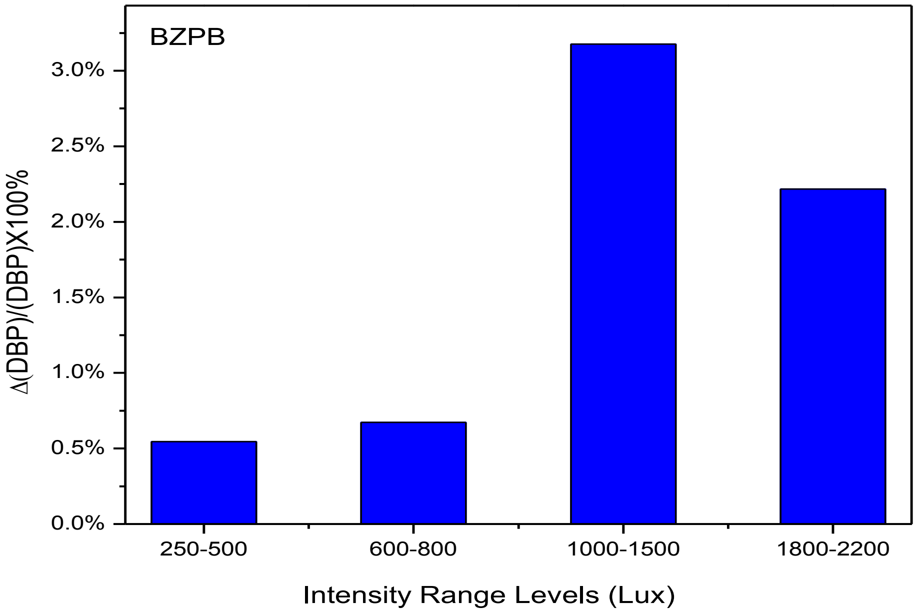

Fig. (3.6): Mean percentage change of DBP for all employees in BZPB versus light intensity range levels (Sig P-value = 0.000)

In Fig. (3.4), the percentage change of DBP in BZBR increases as the light intensity increases, while for DA and BZPB the change increases for the first three intensity ranges and decreases for very high intensity range Figs. (3.5 - 3.6).

The percentage change of DBP in the (248 - 500) Lux range differs slightly from the three companies, while the difference appears for the (600 - 800) Lux range. It is observed that the greatest change in the (600 - 800) Lux range exist in DA.

The percentage change of DBP in the (1000 - 1500) Lux range has the same value (about 3%) for DA and BZPB.

The change of DBP in the case of (1800 - 2200) Lux range, is high especially in BZPR. At the same time it was high in DA and BZPB but it was less than the change in (1000 - 1500) case.

3.4.2 Blood Oxygen Saturation (SPO_2%)

The results of the measured blood oxygen saturation for all employees in the three companies are shown in Table (3.7).

Table (3.7): The average values and standard deviations of the measured SPO_2% for the employees in the selected companies

Company Name	Intensity Level Range (Lux)		SPO_2% (before)	SPO_2% (after)
Birzeit-Ramallah	Low (248 - 500)	Mean	98.04	97.58
		S.D	0.72	0.67
	Normal (600 - 800)	Mean	97.84	97.24
		S.D	0.82	0.84
	High (1000 - 1500)	Mean	98.09	96.89
		S.D	0.89	0.90
	very High (1800 - 2200)	Mean	97.83	96.43
		S.D	1.01	1.40
Dar Al-Shifaa	Low (248 - 500)	Mean	97.46	97.08
		S.D	1.08	0.95
	Normal (600 - 800)	Mean	98.00	97.46
		S.D	0.97	1.05
	High (1000 - 1500)	Mean	97.71	96.96
		S.D	1.07	0.93
	very High (1800 - 2200)	Mean	97.73	96.41
		S.D	1.01	1.04
Birzeit-Birzeit	Low (248 - 500)	Mean	97.81	97.38
		S.D	0.96	0.88
	Normal (600 - 800)	Mean	97.73	96.95
		S.D	0.75	0.93
	High (1000 - 1500)	Mean	98.13	96.63
		S.D	1.00	1.04
	very High (1800 - 2200)	Mean	98.11	96.78
		S.D	0.65	1.44

Table (3.7) shows a decrease in SPO_2% as the employee is exposed to light especially for very high intensity levels.

The absolute percentage change in SPO_2% for all employees in BZPR, DA, and BZPB are displayed in Figs. 3.7, 3.8, and 3.9 respectively.

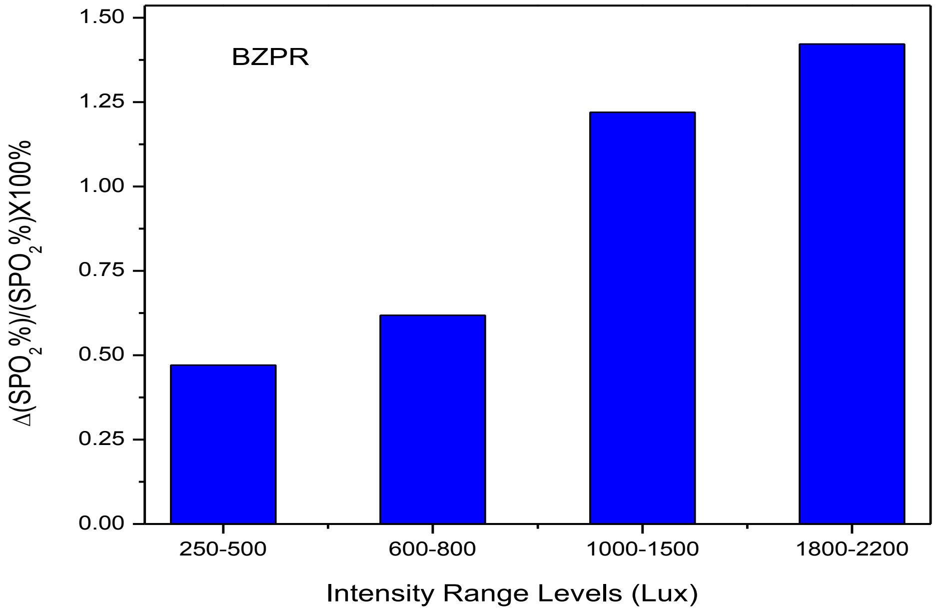

Fig. (3.7): Absolute mean percentage change of SPO_2% for all employees in BZPR versus light intensity range levels (Sig P-value = 0.012)

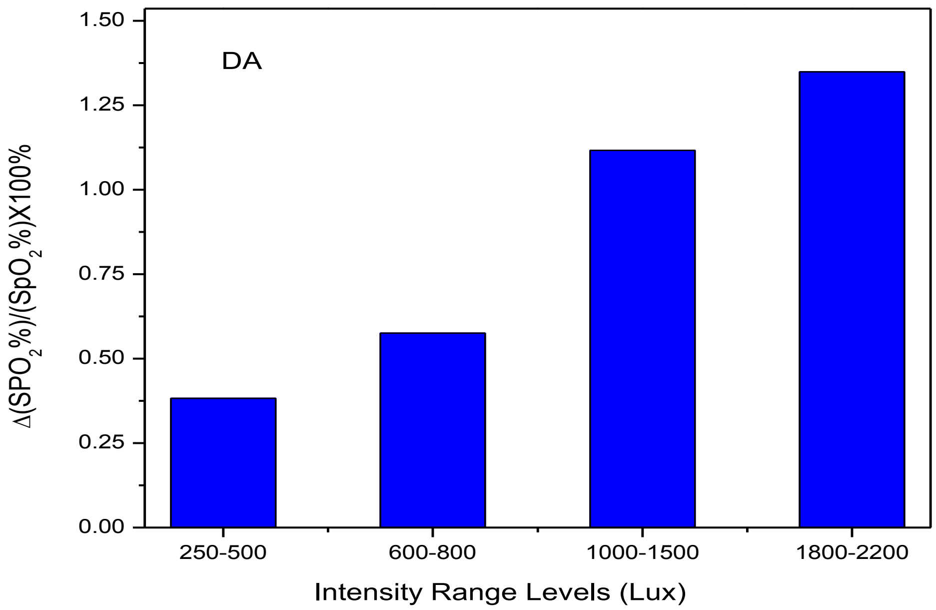

Fig. (3.8): Absolute mean percentage change of SPO_2% for all employees in DA versus light intensity range levels (Sig P-value = 0.003)

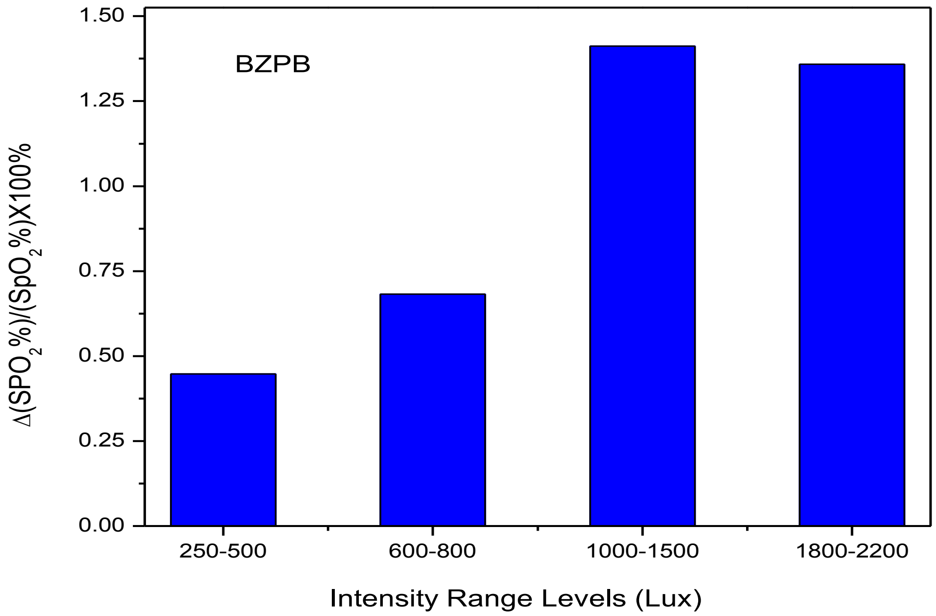

Fig (3.9): Absolute mean percentage change of SPO_2% for all employees in BZPB versus light intensity range levels (Sig P-value = 0.000)

There is a decrease in SPO_2% with increases of light intensity for all employees in all companies and in all intensity ranges. There is slightly change in BZPB when going from high range to very high range.

The SPO_2% was similar between the three companies without any significant changes. For example in (1000 - 1500) Lux case, the change percentage was 1.25% for BZBR while it was 1.12% for DA and 1.40% for BZPB.

3.4.3 Heart Pulse Rate (HPR)

The results of heart pulse rate measurement for all employees in all companies and for all light intensity ranges are shown in Table 3.8.

Table (3.8): The average values and standard deviations of the measured HPR for the employees in the selected companies

Company Name	Intensity Level Range (Lux)		HPR (before) (beat/min)	HPR (after) (beat/min)
Birzeit-Ramallah	Low (248 - 500)	Mean	76.58	75.73
		S.D	10.54	10.05
	Normal (600 - 800)	Mean	74.03	68.71
		S.D	10.55	11.57
	High (1000 -	Mean	74.57	73.70
		S.D	8.66	8.98
	very High (1800 - 2200)	Mean	73.02	76.50
		S.D	11.02	12.09
Dar Al-Shifaa	Low (248 - 500)	Mean	77.38	77.58
		S.D	9.53	9.21
	Normal (600 - 800)	Mean	73.33	73.04
		S.D	8.89	11.93
	High (1000 - 1500)	Mean	75.14	73.46
		S.D	9.64	12.23
	very High (1800 - 2200)	Mean	72.18	73.00
		S.D	10.02	13.25
Birzeit-Birzeit	Low (248 - 500)	Mean	77.88	74.94
		S.D	9.26	9.51
	Normal (600 - 800)	Mean	75.68	68.09
		S.D	10.52	10.89
	High (1000 - 1500)	Mean	72.15	72.67
		S.D	7.57	6.29
	very High (1800 - 2200)	Mean	75.67	79.72
		S.D	11.13	12.02

Figs. (3.10 - 3.12) show the results of measurement of the absolute percentage change for HPR before and after light exposure to light intensity range.

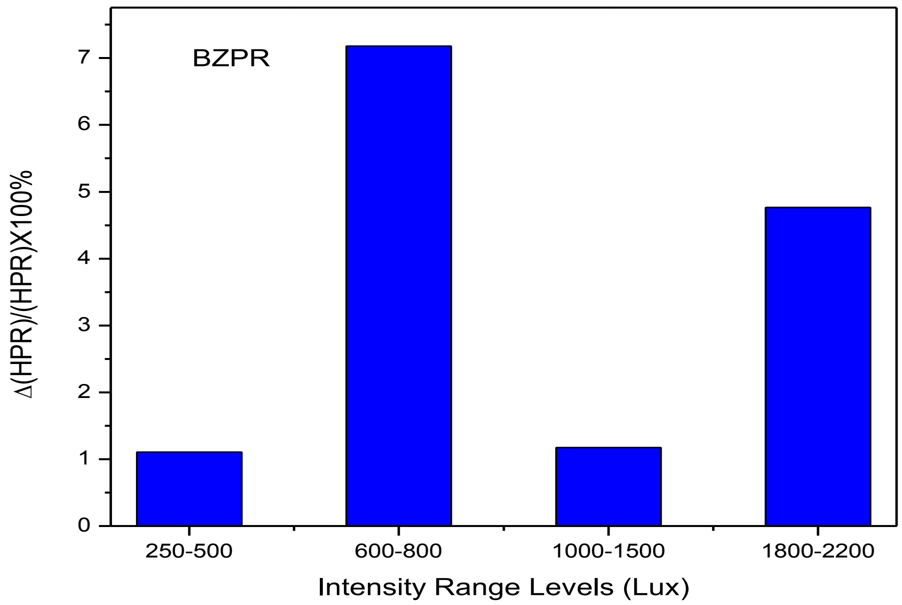

Fig. (3.10): Absolute mean percentage change of HBR for all employees in BZPB versus light intensity range levels (Sig P-value = 0.000)

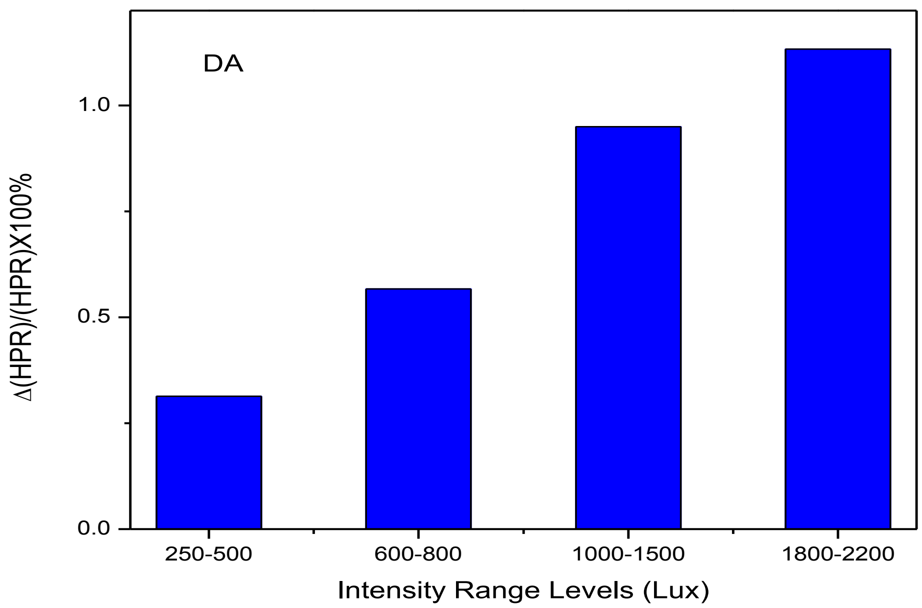

Fig. (3.11): Absolute mean percentage change of HBR for all employees in BZPB versus light intensity range levels (Sig P-value = 0.018)

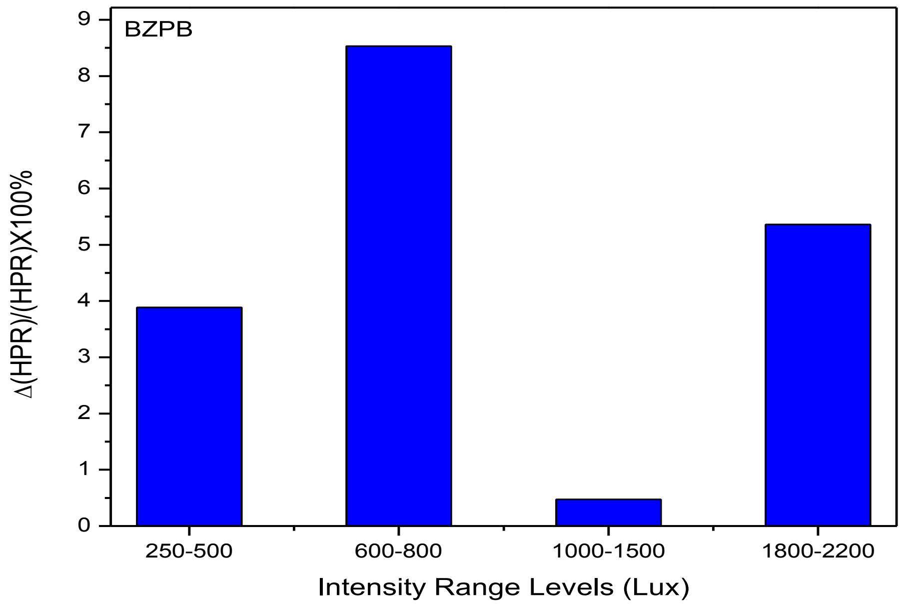

Fig. (3.12): Absolute mean percentage change of SPO_2% for all employees in BZPB versus light intensity range levels (Sig P-value = 0.004)

It is seen from Table 3.8 that the exposing to light affects HPR, but this effect is not regular. There is no rule of the relation between light intensity and heart pulse rate, because sometimes it increases when lights intensity increase and sometimes it decreases, one of the suggested explanations is the interference between the lights waves and the heart pulse waves, where sometimes there is destructive interference so the pulse decreases and sometimes it was constructive so the pulse increases.

The greatest percentage change in heart pulse rate (HPR) in BZPB was measured, and that was in (600 - 800) Lux case. It was about 8%, and the next change was in BZPR in the same range which was (7%) and the least percentage was measured in BZPB in the high intensity range case, while the percentage change was about 1% in (500) Lux case in DA.

3.4.4 Tympanic Temperature (T)

Table 3.9 shows the results of the measurements in all ranges of intensity levels of the tympanic temperature for the employees in the three companies.

Table (3.9): The average values and standard deviations of the measured T for the employees in the selected companies

Company Name	Intensity Level Range (Lux)		T(^{o}C) (before)	T(^{o}C) (after)
Birzeit-Ramallah	Low (248 - 500)	Mean	34.94	35.03
		S.D	0.55	0.47
	Normal (600 - 800)	Mean	34.87	35.36
		S.D	0.60	0.55
	High (1000 - 1500)	Mean	34.45	34.96
		S.D	0.70	0.75
	very High (1800 - 2200)	Mean	34.70	35.29
		S.D	0.56	0.48
Dar Al-Shifaa	Low (248 - 500)	Mean	34.94	35.01
		S.D	0.86	0.72
	Normal (600 - 800)	Mean	34.77	35.16
		S.D	0.56	0.75
	High (1000 - 1500)	Mean	34.70	35.24
		S.D	0.77	0.89
	very High (1800 - 2200)	Mean	34.50	35.10
		S.D	0.69	0.84
Birzeit-Birzeit	Low (248 - 500)	Mean	34.96	35.06
		S.D	0.78	0.63
	Normal (600 - 800)	Mean	34.89	35.45
		S.D	0.71	0.30
	High (1000 - 1500)	Mean	34.91	35.29
		S.D	0.54	0.49
	very High (1800 - 2200)	Mean	34.59	35.21
		S.D	0.49	0.23

Figs. (3.13 - 3.15) display the percentage change of T for the tested employees before and after light exposure against intensity range levels in the three companies.

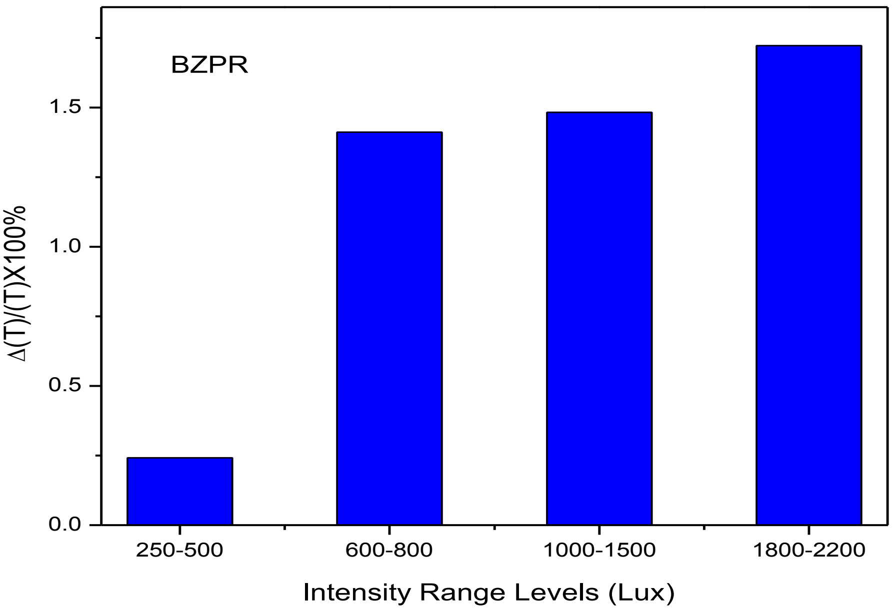

Fig. (3.13): Mean percentage change of T for all employees in BZPR versus light intensity range levels (Sig P-value = 0.007)

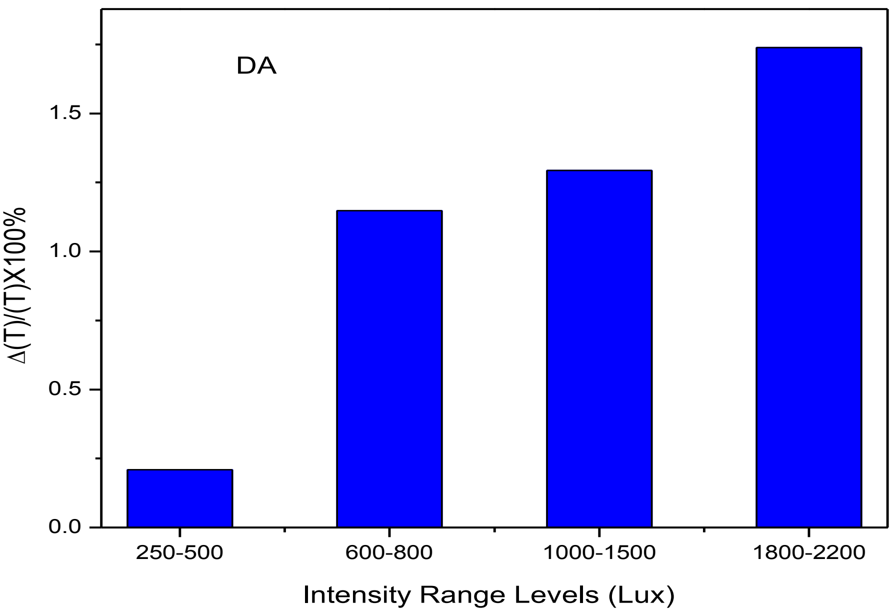

Fig. (3.14): Mean percentage change of T for all employees in DA versus light intensity range levels (Sig P-value = 0.027)

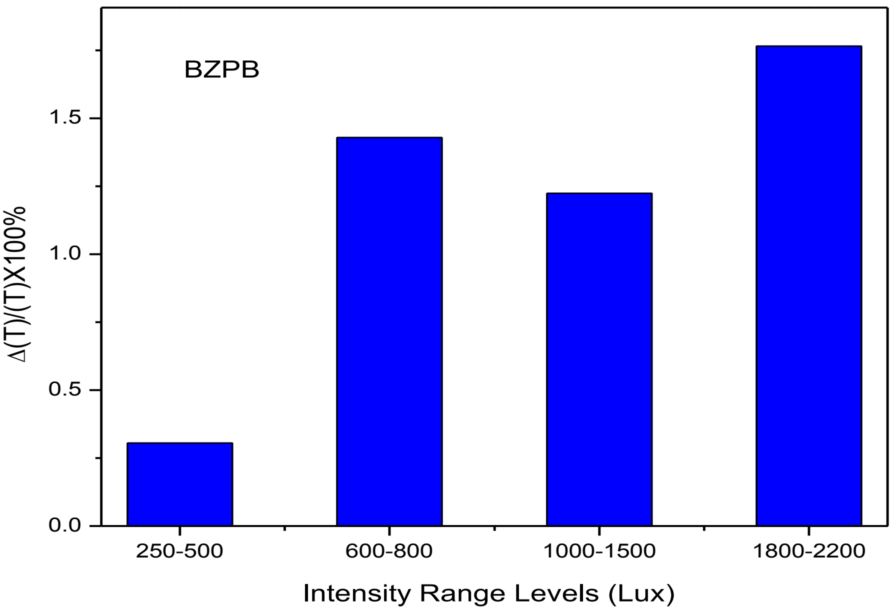

Fig. (3.15): Mean percentage change of T for all employees in BZPB versus light intensity range levels (Sig P-value = 0.009)

The results show change in average tympanic temperature for all intensity range levels of the employees in all companies. As shown in Table 3.9 when employees are exposed to high intensity light, their average tympanic temperature changes from (34.7 - 35.4 ^{o}C) in BZPR, from (34.5 - 35.1 ^{o}C) in DA and from (34.6 - 35.2 ^{o}C) in BZPB .

3.4.5 Age Effect

The ages of the tested employees were classified into three ranges: (17 - 30), (31 - 45), and (> 45) years. The effect of light intensity on SBP, DBP, SPO_2%, HPR, and T according to age range is displayed in Figs. (3.16 - 3.20).

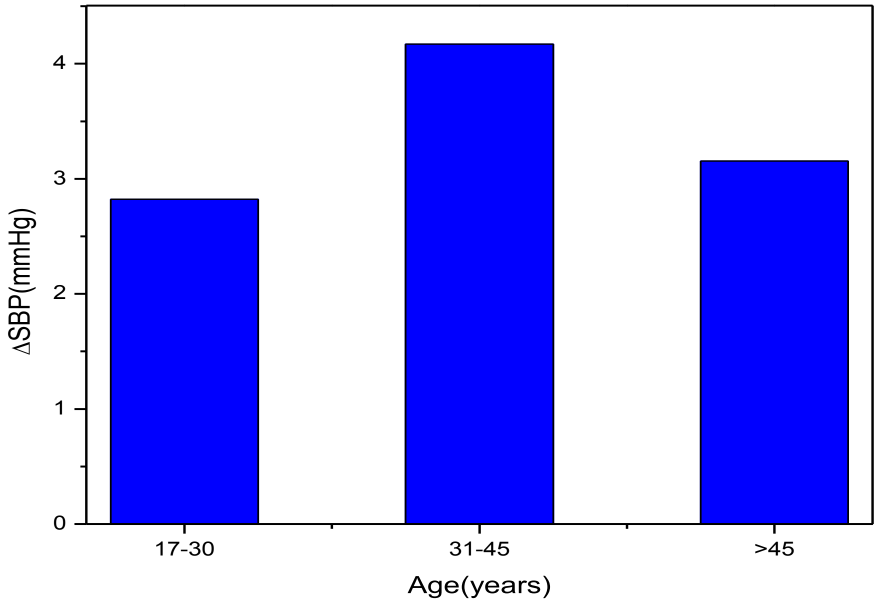

Fig. (3.16): Change of SBP for all employees in all companies against employees ages (Sig P-value = 0.035)

It is observed from Fig. 3.16 that there is no significant difference in change of SBP between the two ranges (17 - 30) and (> 45) years. The change in both ranges is around 3 mmHg.

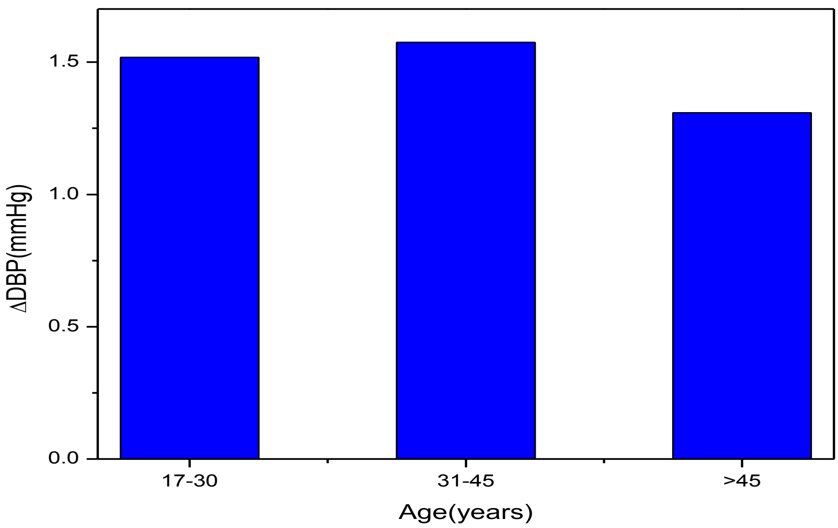

Fig. (3.17): Change of DBP for all employees in all companies against employees ages (Sig P-value = 0.427)

The (31 - 45) years age shows a change equals to 4 mmHg. Light exposure has the greatest effect on the people in the middle age range (31 - 45) years. It is clear from Fig. (3.17), that the change in DBP for all employees does not depend significantly on age of the employee. The value of the change in DBP equals 1.5 mmHg for all ages.

In Fig. 3.18 the change in SPO_2% is displayed against employee's age range. One can see that SPO_2% increases slightly as the age increases, however all values are around 1.

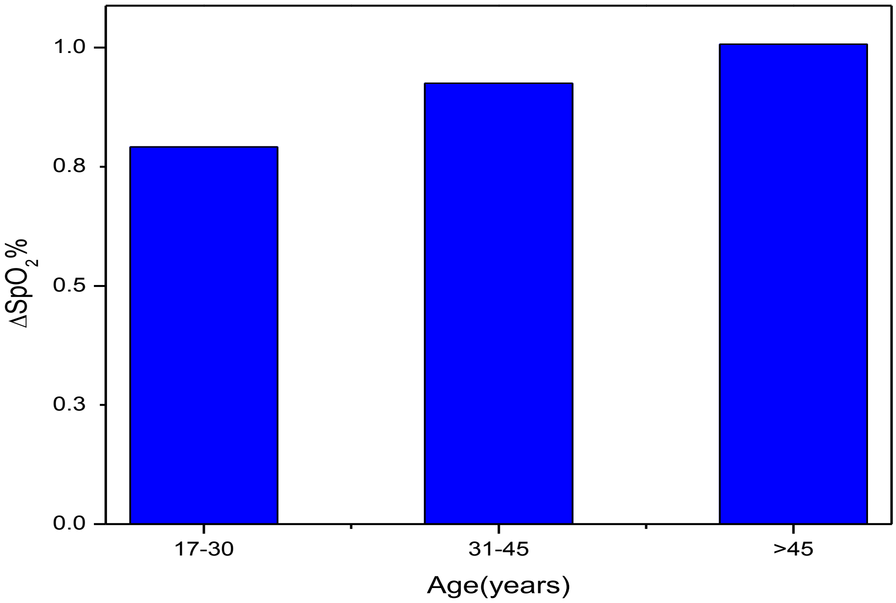

Fig. (3.18): Change of SPO_2% for all employees in all companies against employees ages (Sig P-value = 0.342)

Fig. 3.19 shows the change in HPR versus employees ages for all employees in all companies.

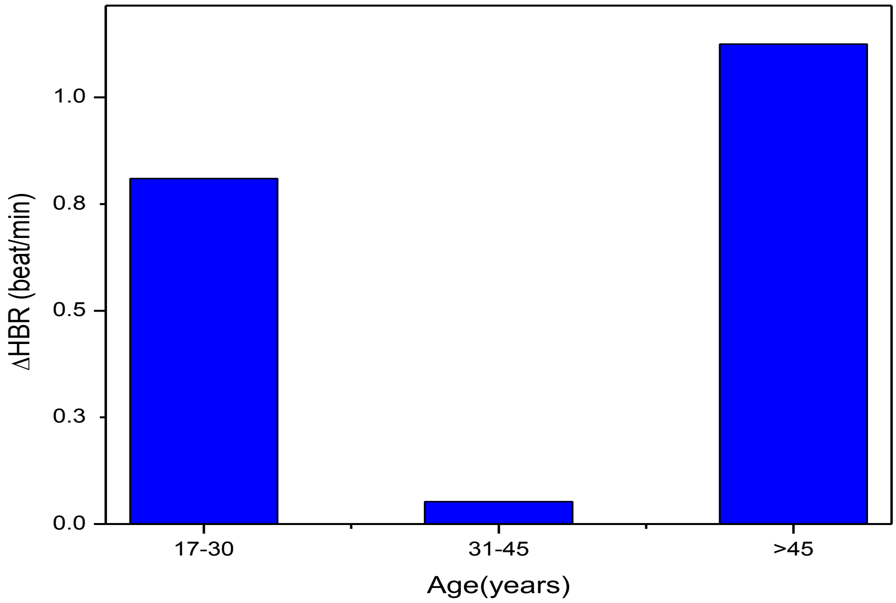

Fig. (3.19): Change of HBR for all employees in all companies against employees ages (Sig P-value = 0.221)

The change in HPR has different values for different age ranges. The values are about 0.8 beat/min in the (17 - 30) years range, where its value is around zero in the middle age range, and it reaches maximum value for older employees.

The change in tympanic temperature against age range for all employees and in all companies is shown in Fig. 3.20.

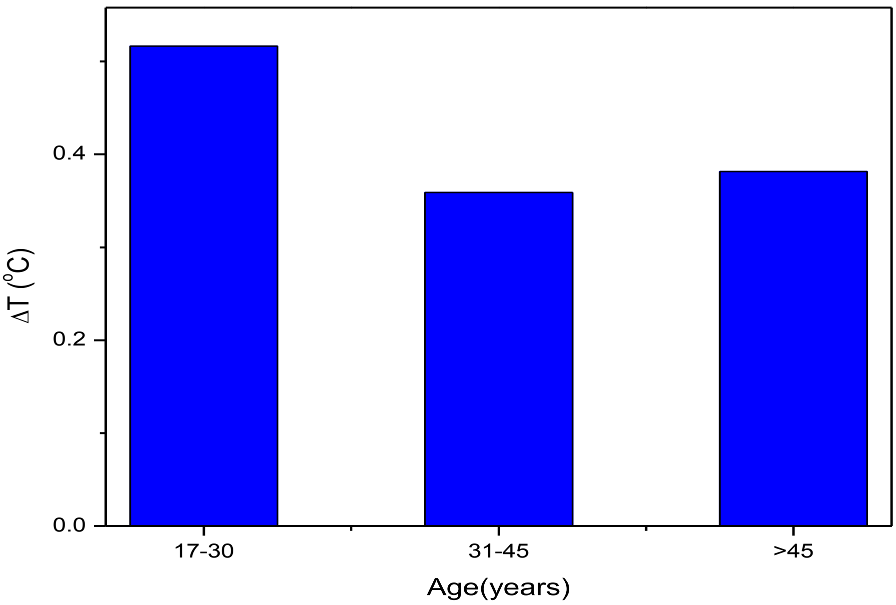

Fig (3.20): Change of T for all employees in all companies against employees ages (Sig P-value = 0.226)

Fig. (3.20) shows that there is no significant change in T due to age, the value of ΔT is around 0.5 ^{o}C for the (17 - 30) years range, 0.35 ^{o}C for the (17 - 30) and 0.35 ^{o}C for the (> 45)years.

3.4.6 Gender Effect

Fig. (3.21) shows change in SBP before and after exposure to light versus gender for all employees in all companies.

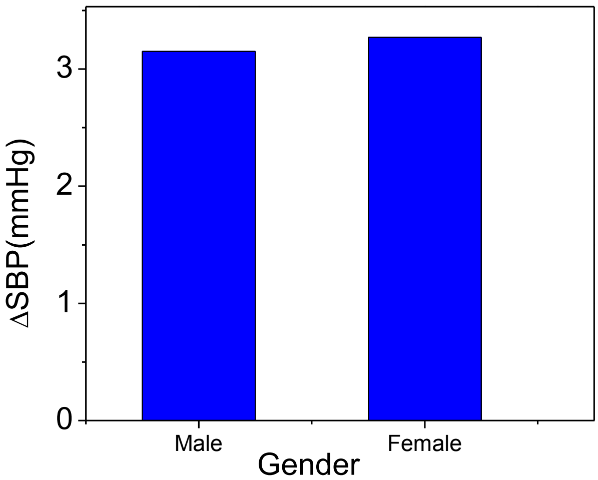

Fig. (3.21): Change of SBP for all employees in all companies against employees gender (Sig P-value = 0.631)

There is no significant change in SBP according to the employee gender where both males and females have the same value of change which is around 3 mmHg.

The change in DBP against gender for all employees is displayed in Fig.(3.22).

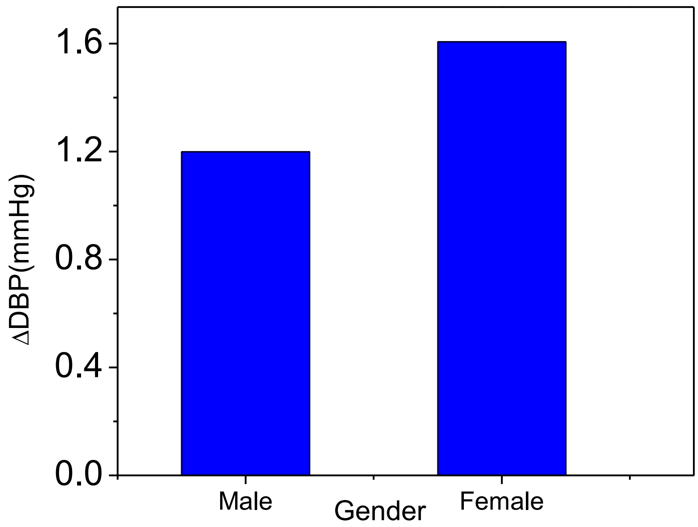

Fig. (3.22): Change of DBP companies for all employees in all against employees gender (Sig P-value = 0.031)

Fig. (3.22) shows significant difference of changes of DBP between males and females. For males the change in DBP is about 1.2 mmHg, while it is 1.6 mmHg for females.

In Figs. (3.23 - 3.25) the change in SPO_2%, HPR, and T are plotted versus employees gender.

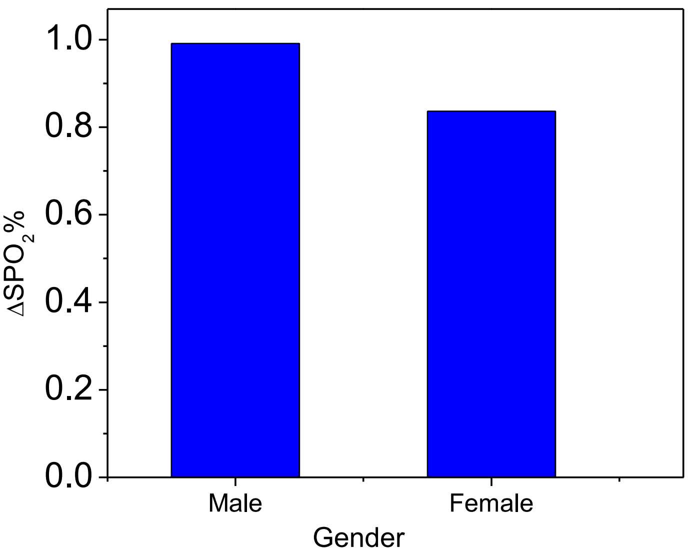

Fig. (3.23): Change of SPO_2% for all employees in all companies against employees gender (Sig P-value = 0.018)

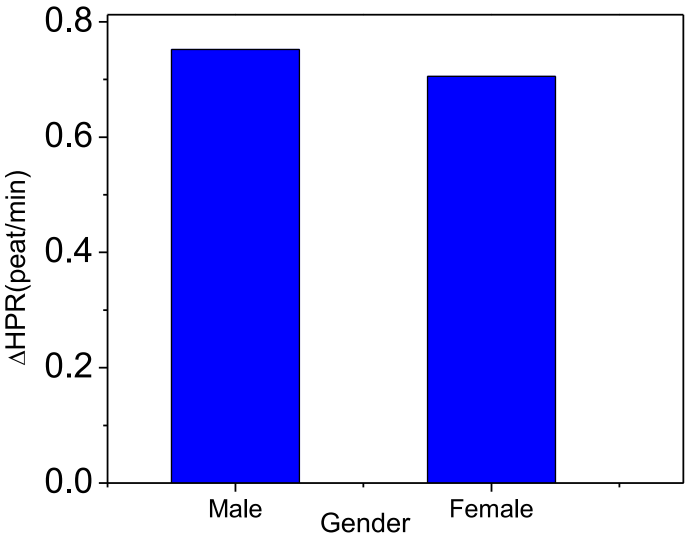

Fig. (3.24): Change of HBR for all employees in all companies against employees gender (Sig P-value = 0.214)

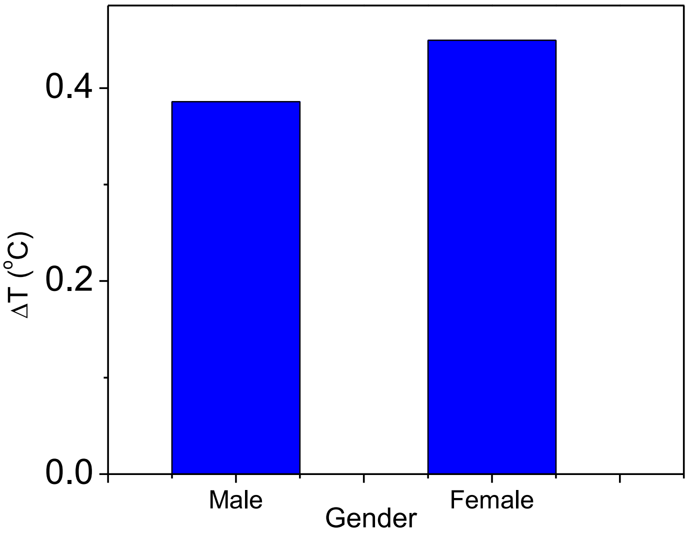

Fig. (3.25): Change of tympanic temperature for all employees in all companies against employees gender (Sig P-value = 0.006)

Figs. (3.23 - 3.25) show a slight difference between males and females in the results of SPO_2%, HPR, and tympanic temperature (T). The values of the differences between males and females are 0.1 for SPO_2%, 0.02 (beat/min) for HPR, and 0.1 ^{o}C for T.

Chapter 4

Discussion and Recommendation

4.1 Discussion

Light intensity was measured in three different pharmaceutical companies in Ramallah city. The range of light intensity is extended from 248 lux, which is registered in Birzeit Company-Ramallah branch, to 2200 lux which is registered in Birzeit company-Birzeit branch (Table 3.4).

The effect of years of work parameter of the employee was neglected. Since there is no enough number of employees that worked in the same working conditions for number of years and this may lead to non-significant results.

In this study the systolic and diastolic blood pressure, heart pulse rate, blood oxygen saturation, and tympanic temperature of the employees were measured before and after workday, and then a relationship between light intensity and the change of parameters were studied. Results showed that there is a relation between light intensity levels and all the health parameters, in general the changes are within the normal levels.

The results of measurement of systolic and diastolic blood pressure show that there are increases in values with an increase of light intensity levels in all companies for all employees, but it still in normal range .The changes in SBP for employees in the middle age range is more than that of young and old age range. The changes in DBP were more on young and middle age than that of older. There is no significant change in SBP according to the employees' gender since both males and females have the same value of change. Females are more affected than males according to DBP results. Strong correlation (Sig P-values) was obtained between light intensity and the change in both SBP and DBP. The results of the change in blood pressure versus light intensity are in good agreement with Pandi's study. He found that the change in blood pressure of nurses that were exposed to 1700 Lux was more than that for nurses that were exposed to 500 Lux. (Pandi *et al*., 2006).

Measurement show that SPO_2% decreases when a light intensity level increases for all employees in all companies, but this changes in the normal range. The change in SPO_2% increases slightly as the age increases. The older employees are affected more than younger ones. The males were more affected than females. Sig P-value between SPO_2% and light intensity levels was measured to be zero, which indicates strong relation between SPO_2% and light intensity. This result is in good agreement with Peng's study which showed that the SPO_2% decreased as the intensity of light increases (Peng *et al*., 2001).

The results of measurement of heart pulse rate indicated that a disturbance in HPR occurred when the employees are exposed to intensity light levels. The change of HBR verses light intensity levels was found to be irregular, however the changes were in normal range. The change of HPR is more for older persons than middle age persons, where the younger persons are less affected. There is slight difference of HPR change between males and females. Strong relation (Sig P-values equal 0.000) was indicated between HPR and light intensity levels.

Some studies indicate that HPR increases while light intensity level increases. Tsunoda and his group study showed an increase in the low frequency-to-high frequency ratio of the heart rate variability after bright light exposure (Tsunoda *et al*., 2001). Other studies indicated that HPR decreases with light intensity such as Gilbert and his group. They found a reduction of the heart pulse rate after exposure to high light intensity level (Gilbert *et al*., 1999). The results of our study showed that there is an effect to HPR but it is irregular.

The results of our study point out that an increase of light intensity will increase tympanic temperature. The same result was obtained for all employees in all companies, but it still in the normal range. The young employees were more affected than the older ones. The females were more affected than males. The (Sig P-value) between tympanic temperature and light intensity was calculated to be 0.002 which indicates a strong relation between tympanic temperature and light intensity. The result of this study is in good agreement with Badia's study. They found that tympanic temperature increases when light intensity level increases (Badia *et al*., 1991).

In general, the results of this study showed that there is a relation between light intensity levels and all the health parameters. Systolic and diastolic blood pressure and tympanic temperature increase as light intensity level increases. SPO_2% decreases as light intensity level increases. But all of them remain in normal range.

Sound pressure levels have effects on health parameters as concluded by Abdelraziq I. R and others. They studied effects of noise pollution on arterial blood pressure, pulse rate and hearing threshold in school children (Ashqar *et al*., 2003). Sadeq and his group studied the effects of noise pollution on SBP, DBP, and HPR, and found that these parameters are correlated positively with the occupational noise levels (Sadeq *et al*., 2012). The range of the noise pressure in our study was measured to be (40.2 - 55.3) dB with average (46.8) dB. This value of noise pressure level is considered to be quite (acceptable).

4.2 Recommendations

Some recommendations are carried out to reduce the effect of high light intensity on employees in pharmaceutical companies.

1- Inspecting and watching the light intensity levels in different working places to make sure that they do not exceed the international health organizations standards, which is from(600 – 800).

2- The light source should be localized such that it lights the working area without being extended to the whole room. This will minimize the light intensity on the employees.

3- Following up with medical checks for all employees to avoid health risks resulting from high intense light.

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Appendix A

The measured values of SPB (mmHg), DPB (mmHg), SPO2%, HBR (beat/min), and T(^{o}C) versus light intensity levels of the employees for all companies of BZPR, DA, and BZPB

NO.	Light Intensity (LUX)	Age	Gender	Company	Sound Pressure.(dB)	SBP B1	SBP B2	SBP A1	SBP A2	DBP B1	DBP B2	DBP A1	DBP A2	SPO B1	SPO B2	SPO A1	SPO A2	HBR B1	HBR B2	HBR A1	HBR A2	T B1	T B2	T A1	T A2
1	1074	44	1	1	46.6	111	108	110	113	75	79	80	79	99	98	97	99	77	75	83	84	34.4	34.4	34.6	34.7
2	1487	32	1	1	49.8	112	117	119	117	79	76	79	81	97	97	96	97	77	78	80	80	34	34	34.2	34.3
3	1418	28	1	1	49.3	110	119	120	115	82	83	84	87	98	99	97	96	76	74	71	74	33	33.1	35	35.1
4	630	56	2	1	43.2	135	136	140	139	79	73	79	79	98	99	97	97	77	78	65	70	34.4	34.4	34.7	34.6
5	248	24	1	1	40.2	138	132	148	134	80	82	84	85	99	98	99	99	85	89	84	81	34.9	35	34.7	34.8
6	2200	37	1	1	55.2	135	129	137	135	82	78	80	86	97	97	94	94	54	57	63	61	35.9	35.9	36.2	36.1
7	1196	25	1	1	47.6	117	118	128	125	77	78	76	75	99	99	98	97	84	82	79	81	34.5	34.6	35.6	35.5
8	630	36	1	1	43.2	133	126	131	134	89	85	70	75	99	99	97	97	51	57	49	55	35.4	35.3	35.7	35.6
9	1877	60	2	1	52.9	131	126	130	132	75	73	75	74	98	97	96	96	64	62	64	65	35.1	35	35.3	35.4
10	1989	46	1	1	53.7	87	87	105	102	71	64	73	73	99	99	99	99	74	72	78	79	35.7	35.6	36.1	36.2
11	248	54	1	1	40.2	83	92	85	83	68	64	67	60	99	99	98	98	77	80	81	81	34.9	34.9	34.9	35
12	2040	38	1	1	54.1	112	110	123	122	77	77	78	76	97	97	95	95	74	74	66	68	34.2	34.2	36.2	36.2
13	248	29	1	1	40.2	98	107	100	98	68	64	67	60	98	98	97	97	80	83	84	84	34.9	34.9	34.9	35
14	1347	43	2	1	48.7	116	122	127	122	76	77	75	77	99	99	98	97	91	89	86	88	33.5	33.6	34.6	34.5

15	680	32	1	1	43.6	111	103	103	114	68	73	75	73	98	97	97	97	79	79	72	71	35.5	35.4	35.9	35.8
16	1196	21	1	1	47.6	108	110	111	115	69	67	74	72	98	99	96	97	78	76	66	70	33.8	33.9	34.3	34.2
17	2200	23	1	1	55.2	130	132	145	142	66	69	68	77	99	99	96	96	72	71	77	77	34.1	34.2	34.8	34.9
18	1074	21	2	1	46.6	116	117	119	123	66	71	71	69	98	99	97	98	92	89	86	83	35.1	35	35.2	35.1
19	1989	25	1	1	53.7	164	158	176	174	80	80	84	87	97	97	96	96	84	85	86	87	35	35.1	34.9	34.9
20	630	43	2	1	43.2	131	128	119	119	80	74	74	75	98	98	98	97	71	71	67	36	34.3	34.2	35.7	35.7
21	1487	42	1	1	49.8	135	134	158	150	81	85	86	83	99	98	97	98	80	87	86	84	34.5	34.5	34.8	34.9
22	1877	30	2	1	52.9	158	156	169	168	77	77	83	82	96	96	94	94	73	73	65	67	34.2	34.2	36.2	36.2
23	1989	28	1	1	53.7	137	130	145	139	67	65	70	70	97	98	95	95	64	66	69	69	34.5	34.5	35.5	35.6
24	768	50	1	1	44.2	129	122	129	131	82	78	67	70	98	98	96	96	53	59	51	57	34.3	34.2	35.7	35.7
25	1487	43	1	1	49.8	108	112	118	115	74	73	80	81	98	99	97	96	72	70	67	70	33	33.1	34.2	34.1
26	1418	30	1	1	49.3	126	119	123	128	64	67	66	68	97	96	98	99	60	53	50	51	35.3	35.3	34.4	34.5
27	1487	28	1	1	49.8	125	122	123	124	82	79	73	79	96	97	98	97	71	75	81	79	34.8	34.9	35.8	35.7
28	248	45	2	1	40.2	95	98	108	107	61	66	67	69	98	98	97	98	87	86	84	86	34.9	34.9	34.2	34.3
29	680	22	1	1	43.6	127	128	128	130	70	73	74	70	97	97	97	96	78	78	79	79	35.6	35.5	35.7	35.6
30	1074	20	1	1	46.6	113	115	117	120	70	73	76	77	99	99	96	96	81	81	90	86	34.6	34.7	35	34.9
31	630	53	2	1	43.2	123	127	119	108	70	68	62	62	99	99	99	99	60	63	64	64	33.9	33.8	35.2	35.1
32	1347	24	1	1	48.7	109	101	108	108	63	64	63	64	99	96	97	97	73	70	65	63	34.2	34.2	33.8	33.9
33	2200	20	1	1	55.2	188	189	183	193	75	72	74	78	97	97	97	96	94	96	90	92	33.7	33.7	35.1	35
34	2040	41	2	1	54.1	124	118	136	134	80	80	84	88	98	98	97	97	78	79	80	81	35	35.1	34.9	34.9
35	1347	30	2	1	48.7	123	120	134	130	79	75	82	81	98	99	96	96	86	84	71	79	34.4	34.3	36.4	36.3
36	768	31	2	1	44.2	121	118	120	122	60	54	61	67	98	97	97	98	73	73	65	66	34.8	34.7	35.6	35.6
37	1347	23	2	1	48.7	103	113	110	112	81	78	81	83	96	96	95	96	73	74	76	76	33.9	33.9	34.2	34.3
38	1347	48	1	1	48.7	122	117	125	128	77	77	78	82	98	98	97	98	64	61	59	61	34.4	34.4	34.2	34.3
39	248	32	1	1	40.2	113	114	105	116	88	90	82	80	98	97	98	96	59	64	57	58	35	35.1	34.9	35
40	715	39	2	1	43.8	104	96	94	106	64	69	70	67	99	98	98	98	78	78	71	70	35	34.9	35.6	35.5
41	312	27	1	1	40.7	125	125	118	121	75	68	73	69	98	98	97	97	74	72	74	76	33.9	33.9	34.8	34.9
42	680	42	1	1	43.6	140	135	135	135	90	92	94	90	98	98	98	98	71	77	60	62	35.7	35.6	35.4	35.4
43	1196	72	1	1	47.6	119	122	126	128	78	79	83	83	96	97	96	96	57	62	63	60	34	34.1	35.1	35
44	715	39	2	1	43.8	155	150	152	151	87	89	92	89	97	97	97	97	76	82	65	67	35.2	35.1	35.7	35.7

45	1877	29	1	1	52.9	112	119	120	118	73	77	69	74	96	96	97	97	70	68	87	85	35	35.1	34.7	34.7
46	1487	26	1	1	49.8	121	128	123	128	65	68	71	72	98	98	95	95	77	77	86	82	33.6	33.7	34	33.9
47	1074	50	2	1	46.6	112	115	108	110	74	75	72	73	98	98	96	97	62	64	69	68	34.8	34.9	35.5	35.6
48	790	54	2	1	44.4	124	120	124	128	81	71	73	76	97	97	98	97	93	93	87	84	34.6	34.5	34.7	34.6
49	790	17	2	1	44.4	133	129	135	138	76	66	69	73	96	96	96	96	89	89	83	80	35.2	35.1	35.7	35.7
50	630	19	2	1	43.2	102	123	112	111	60	59	67	70	99	98	98	98	71	80	61	74	34.6	34.5	34.4	34.4
51	715	33	1	1	43.8	118	118	134	120	73	75	82	80	98	98	99	98	60	62	58	64	36	36	35.8	35.9
52	312	42	2	1	40.7	128	129	120	131	78	80	72	68	98	97	98	96	65	70	63	64	35	35.1	34.9	35
53	1120	28	1	1	47.0	118	114	122	124	79	82	86	82	97	98	97	98	70	71	72	73	34.7	34.7	34.4	34.5
54	2040	37	2	1	54.1	120	123	120	117	76	77	78	78	99	99	97	97	59	57	57	59	34.2	34.3	35	35
55	312	29	1	1	40.7	113	109	103	106	70	66	64	61	99	98	97	98	64	60	68	69	35.1	35.1	34.8	34.9
56	312	18	1	1	40.7	105	106	115	111	63	59	69	70	99	99	98	98	67	66	69	67	34.3	34.4	34.8	34.9
57	1487	42	1	1	49.8	115	115	126	121	79	79	80	84	98	98	97	98	71	68	66	68	35.4	35.4	35.2	35.3
58	1877	58	2	1	52.9	147	140	155	149	67	65	70	70	97	98	95	95	57	59	62	62	34.5	34.5	35.5	35.6
59	630	60	2	1	43.2	132	131	140	145	79	73	79	78	98	98	98	97	81	80	72	69	34.9	34.8	36	36.1
60	2200	43	2	1	55.2	39	41	52	45	82	79	85	83	98	98	98	98	82	83	105	85	35.1	35.2	35	35
61	2040	50	1	1	54.1	125	119	127	125	82	78	80	82	98	98	95	95	60	63	69	67	34.9	34.9	35.2	35.1
62	2040	39	2	1	54.1	128	135	136	134	73	77	69	74	97	97	98	98	71	69	88	86	35	35.1	34.7	34.7
63	407	30	2	1	41.4	131	130	133	135	85	80	83	85	99	99	98	98	72	72	75	73	34.9	34.8	36.2	36.1
64	1487	20	1	1	49.8	137	141	135	142	86	90	89	91	99	98	95	96	77	75	74	72	35.6	35.7	36.6	36.5
65	1877	53	2	1	52.9	153	148	152	154	75	73	75	74	98	97	96	96	68	66	68	69	35.1	35	35.3	35.4
66	1347	19	1	1	48.7	125	124	123	125	81	80	79	81	99	98	95	96	81	79	78	76	34.6	34.7	35.6	35.5
67	1989	48	2	1	53.7	152	154	165	158	82	79	81	83	99	99	99	99	87	88	110	90	35.1	35.2	35	35
68	2040	45	2	1	54.1	134	130	137	135	68	63	80	80	99	99	97	97	85	83	75	72	34.3	34.3	35.2	35.2
69	1074	30	2	1	46.6	122	130	118	120	65	66	63	64	99	99	97	98	69	71	76	75	35.8	35.9	36.5	36.6
70	407	35	2	1	41.4	152	146	162	148	84	86	96	91	98	97	98	98	87	91	86	83	35.9	36	35.7	35.8
71	1487	22	1	1	49.8	129	125	120	125	74	78	82	80	99	99	98	97	70	72	68	67	34.2	34.3	34.3	34.2
72	680	32	1	1	43.6	116	117	119	119	80	80	80	80	97	98	96	96	86	84	92	88	35	34.9	35.3	35.4
73	1877	34	1	1	52.9	124	125	119	129	75	76	74	78	97	97	97	96	90	92	86	88	33.7	33.7	35.1	35
74	2200	35	1	1	55.2	120	123	120	117	76	77	78	78	99	99	96	96	64	62	62	64	34.2	34.3	35	35

75	680	55	2	1	43.6	120	120	126	121	69	63	74	75	97	97	96	97	60	69	58	61	33.9	33.8	34	34.1
76	2040	23	1	1	54.1	120	121	128	135	76	73	70	70	99	99	97	97	80	82	89	91	34.6	34.5	35.6	35.6
77	1347	22	2	1	48.7	117	120	124	125	76	78	81	81	99	99	98	98	63	62	67	64	34	33.9	35.2	35.1
78	407	28	1	1	41.4	128	113	114	114	84	73	79	86	97	97	98	98	70	84	68	70	34.5	34.4	34.9	34.8
79	407	58	2	1	41.4	103	106	116	115	64	63	64	66	97	97	96	97	94	93	91	93	35.9	35.9	35.2	35.3
80	1989	32	2	1	53.7	102	102	120	117	69	62	71	71	99	99	98	98	75	73	79	80	34.7	34.6	35.1	35.2
81	1418	38	2	1	49.3	122	127	124	127	77	75	75	76	97	98	97	97	87	72	75	74	35.3	35.3	35.3	35.4
82	1418	44	2	1	49.3	126	130	130	128	69	68	71	67	99	99	97	98	81	85	74	75	34.5	34.6	34.9	34.8
83	680	27	2	1	43.6	124	119	125	120	82	79	82	80	99	99	97	97	76	78	89	86	35	34.9	35.1	35.2
85	790	46	2	2	44.4	112	105	110	112	62	61	64	64	97	98	97	96	76	78	73	76	35	35	35.5	35.6
86	630	30	1	2	43.2	104	107	106	113	66	71	69	75	97	98	98	97	61	61	69	72	35	34.9	35.7	35.8
87	363	31	1	2	41.1	113	114	123	119	62	64	68	69	98	98	97	97	67	66	69	67	33.8	33.8	33.8	33.9
88	2200	40	1	2	55.2	109	112	109	106	73	74	77	75	99	99	97	97	59	57	57	59	33.2	33.3	34.5	34.4
89	715	44	2	2	43.8	124	121	127	131	69	70	71	76	99	99	98	99	78	82	80	94	34.9	35	35.1	35.3
90	1347	35	2	2	48.7	111	109	118	120	83	85	88	87	99	99	96	96	72	75	79	79	35.1	35	35.4	35.4
91	363	22	2	2	41.1	115	113	120	122	92	93	94	94	97	97	98	98	77	78	74	75	34.6	34.5	34.7	34.6
92	2200	31	2	2	55.2	105	104	119	115	70	75	75	74	99	99	98	98	70	75	84	80	34.7	34.7	35.5	35.4
93	439	24	2	2	41.7	115	114	123	107	95	78	85	85	98	97	97	97	58	62	72	68	34.7	34.6	34.6	34.7
94	1347	47	1	2	48.7	176	172	148	150	93	90	95	95	96	96	95	95	87	87	90	92	34.6	34.5	35.7	35.7
95	439	47	2	2	41.7	110	114	122	121	65	66	72	69	95	96	96	96	88	86	82	85	36	35.9	36	36
96	630	33	1	2	43.2	119	130	149	141	86	83	90	92	99	98	96	97	87	86	101	108	35.4	35.4	35.6	35.7
97	790	19	1	2	44.4	129	127	134	137	93	88	90	93	98	98	96	97	70	73	69	72	34.1	34.1	34.2	34
98	439	24	2	2	41.7	124	130	120	127	85	83	81	81	97	97	97	98	81	82	93	81	35.4	35.3	35.7	35.6
100	768	34	2	2	44.2	115	108	110	105	75	72	75	74	98	98	98	98	78	78	85	89	34.6	34.9	35.9	35.8
101	715	23	2	2	43.8	136	142	132	139	91	89	87	87	97	97	99	98	81	82	93	81	36	35.9	36	36
101	715	23	2	2	43.8	136	134	132	139	85	87	87	87	97	97	97	98	81	82	93	81	36	36	35.7	36
102	680	116	2	2	43.6	120	117	119	120	70	73	76	72	96	96	95	95	80	80	81	81	35.2	35.3	35.7	35.7
103	715	27	2	2	43.8	124	109	110	110	74	63	69	76	98	98	99	99	74	88	72	74	34.7	34.7	36	36
104	715	45	1	2	43.8	134	121	135	130	88	83	74	76	98	98	98	98	75	74	69	70	35	34.9	35.4	35.4
105	1418	51	1	2	49.3	118	116	123	125	66	76	74	74	97	97	97	96	64	64	66	64	34.6	34.5	34.8	34.8

106	715	23	1	2	43.8	138	125	139	134	81	76	67	69	99	99	99	99	82	81	76	77	34.7	34.6	35.3	35.2
107	680	23	1	2	43.6	130	128	121	122	90	91	92	92	96	96	99	99	83	84	80	81	34.9	34.8	35.2	35.1
108	1418	21	1	2	49.3	109	103	108	110	59	60	59	60	99	96	97	97	69	66	61	59	33.7	33.6	33.8	33.8
109	680	37	1	2	43.6	116	115	118	120	82	72	82	83	99	99	98	98	70	70	73	71	34.6	34.5	35	35.1
110	630	17	1	2	43.2	138	124	124	127	80	81	85	88	99	98	98	98	70	70	73	69	34.7	34.7	37.5	37.4
111	790	23	1	2	44.4	140	145	145	147	80	81	86	90	99	99	97	97	55	60	52	53	34.6	34.5	34.2	34.1
112	630	33	2	2	43.2	128	127	138	138	87	81	89	87	99	99	99	98	75	74	66	63	35.2	35.3	35.9	35.8
113	680	47	2	2	43.6	114	115	119	118	88	88	90	90	98	99	97	97	83	81	89	85	34.7	34.6	34.4	34.5
114	768	23	1	2	44.2	123	127	135	134	68	69	75	72	96	97	97	96	82	80	76	79	35.1	35	35.3	35.2
115	1418	27	1	2	49.3	117	111	114	116	70	65	70	68	99	99	98	97	79	75	70	75	34	33.9	34.7	34.7
116	680	49	2	2	43.6	142	143	149	147	70	64	74	72	99	99	98	98	71	72	59	64	35.8	35.8	36	36
117	1418	28	1	2	49.3	104	104	112	114	66	61	72	68	97	97	98	97	73	73	70	68	34.4	34.3	35	35
118	1347	34	1	2	48.7	132	138	136	138	63	64	67	63	98	98	96	97	86	90	79	80	35.5	35.6	35.9	35.8
119	630	45	1	2	43.2	114	114	118	114	70	64	75	74	96	96	97	97	64	73	62	65	34.9	34.8	36	36.1
120	630	52	2	2	43.2	107	128	119	117	59	58	63	65	99	98	98	98	78	87	68	81	34.7	34.7	35	34.9
121	1418	33	1	2	49.3	115	113	122	124	73	71	71	72	99	98	99	98	64	64	56	57	34.6	34.5	34.8	34.8
122	630	50	2	2	43.2	126	125	134	118	85	68	75	75	98	97	97	97	63	67	77	73	35.1	35	35.3	35.2
123	1487	50	1	2	49.8	106	105	109	111	69	73	76	75	98	97	96	98	80	78	86	87	35.4	35.4	35.6	35.7
124	630	33	2	2	43.2	106	106	106	104	71	71	71	74	99	98	97	98	75	71	65	64	34.3	34.3	33.5	33.6
125	680	23	1	2	43.6	132	120	137	133	80	74	75	71	98	99	98	99	72	70	71	65	34	34.1	34.1	34
126	630	35	1	2	43.2	134	129	137	131	79	76	77	79	99	99	98	98	75	77	88	85	34.8	34.9	35.6	35.5
127	1989	43	1	2	53.7	219	213	221	219	82	78	82	86	97	98	94	94	64	67	73	71	34.9	34.9	35.2	35.1
128	768	24	2	2	44.2	121	125	131	114	80	83	83	85	98	97	98	98	88	85	86	82	35	35	35.5	35.4
129	1347	23	2	2	48.7	123	118	127	129	63	66	65	70	96	95	97	98	59	52	49	50	34.3	34.3	33.8	39.9
130	1347	25	2	2	48.7	116	114	122	124	67	72	72	74	98	99	97	96	77	79	73	79	34.4	34.3	34.8	34.8
131	768	25	2	2	44.2	121	118	122	127	65	66	66	70	99	99	98	97	77	81	79	93	34.4	34.5	35.7	35.6
132	680	54	2	2	43.6	142	131	124	122	68	67	69	63	99	99	98	98	69	69	62	63	34.4	34.5	35.2	35
133	680	20	1	2	43.6	106	104	110	107	65	61	66	68	98	98	98	97	67	72	68	61	35.4	35.4	35.6	35.5
134	768	34	2	2	44.2	124	128	122	110	76	74	70	70	99	99	98	99	64	67	68	68	34.3	34.2	34.8	34.7
135	768	19	1	2	44.2	126	119	125	130	70	62	69	71	99	98	97	98	49	50	45	45	33.7	33.9	34.3	34.4

136	1487	43	2	2	49.8	136	143	138	140	69	64	67	68	97	98	96	97	89	74	77	76	36.3	36.3	36.3	36.4
137	680	44	2	2	43.6	144	132	149	145	86	80	81	77	99	98	97	98	77	75	76	70	34.6	34.6	34.6	34.5
138	680	25	1	2	43.6	118	106	116	109	76	74	70	71	99	99	99	98	59	63	62	60	34.8	34.8	35.1	35.3
139	1347	60	1	2	48.7	126	124	135	137	67	70	76	75	98	99	98	99	77	78	79	80	33.7	33.7	33.7	33.8
140	790	31	2	2	44.4	113	117	130	121	78	78	80	82	99	98	98	97	84	86	70	84	35.1	35.1	35.8	35.7
141	630	35	2	2	43.2	98	94	88	91	72	68	66	63	99	98	97	98	65	61	69	70	33.7	33.6	34	34.1
142	768	39	1	2	44.2	107	107	120	110	81	83	87	90	99	99	99	99	57	59	55	61	35.1	35.2	35.7	35.8
143	2040	50	1	2	54.1	150	151	158	165	86	83	72	70	98	98	96	96	84	86	93	95	34.4	34.5	35.6	35.6
144	790	43	2	2	44.4	115	112	116	117	60	54	63	69	97	96	96	97	74	74	66	67	35.5	35.5	35.9	36
145	630	20	1	2	43.2	117	114	107	106	77	71	73	74	98	98	96	97	68	68	64	33	34.7	34.6	35.3	35.5
146	680	63	1	2	43.6	125	123	123	126	75	64	70	69	97	97	95	96	56	63	62	62	33.5	33.7	33.9	33.7
147	2040	33	1	2	54.1	123	117	135	133	73	73	79	87	98	97	96	96	83	84	85	86	35	35.1	34.9	34.9
148	1347	41	1	2	48.7	128	129	151	153	69	73	78	76	99	98	97	97	83	90	89	87	35.5	35.5	35.8	35.9
149	768	46	1	2	44.2	125	108	111	111	75	64	69	77	98	97	97	98	66	65	69	67	33.5	33.5	34	34.1
151	439	24	2	2	41.7	105	109	102	103	66	69	71	61	98	98	98	97	84	89	84	80	33.9	34	34.7	34.7
153	1989	64	2	2	53.7	125	117	135	135	73	72	79	86	99	97	96	96	73	72	61	62	34.9	34.8	35.8	35.7
154	363	60	1	2	41.1	110	110	116	106	65	64	71	69	97	99	97	98	86	87	74	76	35.9	36	34.2	34.3
156	1989	47	2	2	53.7	119	114	120	119	83	78	81	86	96	96	98	97	81	83	94	80	35	34.9	37.3	35.4
159	768	19	2	2	44.2	130	124	138	133	82	77	67	68	99	98	98	97	81	80	77	77	34.7	34.6	34.7	34.9
160	439	49	1	2	41.7	130	128	134	126	70	64	72	65	96	95	98	97	84	84	80	80	34.9	33.8	36	34.1
161	790	21	1	2	44.4	130	128	120	122	91	90	92	92	98	99	99	97	69	71	73	70	35.6	35.5	34.6	34.8
162	2200	51	1	2	55.2	105	105	118	116	71	74	76	73	98	99	97	96	55	60	53	52	34.4	33.5	33	33.1
163	2040	50	2	2	54.1	150	152	159	164	86	83	72	70	96	96	97	97	83	79	75	78	35.1	36	36.1	34.2
164	768	20	2	2	44.2	136	143	132	135	90	89	86	86	100	98	96	97	73	74	80	78	34.3	34.1	34.7	34.4
165	680	22	1	2	43.6	141	144	146	147	81	80	87	87	96	95	96	96	88	88	91	93	34.7	34.5	35	35
166	2040	60	2	2	54.1	123	117	136	133	72	74	80	86	98	98	96	97	64	63	65	63	33.6	33.5	35.8	34.8
167	768	57	1	2	44.2	122	126	136	135	68	68	76	71	100	95	98	98	70	65	60	59	34.5	34.6	35	34.8
169	2200	55	2	2	55.2	109	113	109	107	74	74	78	74	98	97	96	96	74	72	71	69	34.4	34.3	36	34
171	439	24	1	2	41.7	125	96	111	102	70	65	69	67	99	99	98	97	64	63	56	57	34.6	33.5	35.8	34.8
172	363	60	1	2	41.1	118	106	102	110	70	62	61	61	98	97	97	98	81	78	87	87	36.4	36.4	36.6	35.7

175	439	40	2	2	41.7	143	130	143	138	83	83	95	90	98	99	98	97	71	74	84	79	35.7	34.7	34.5	36.4
176	790	31	2	2	44.4	135	120	129	129	88	82	73	77	98	96	94	94	65	67	74	71	35.4	35.3	34.2	34.4
177	630	24	2	2	43.2	117	116	118	121	81	73	81	82	97	98	96	97	85	86	93	96	34.3	34.5	34.5	35.5
179	363	60	1	2	41.1	124	129	126	127	82	78	68	63	98	98	95	94	82	85	86	86	35	35.1	34.9	33.9
180	709	39	1	3	43.8	128	130	123	131	77	80	77	71	98	98	95	97	53	60	50	57	34.2	34.2	35.7	35.7
181	1404	29	2	3	49.2	118	120	118	120	66	73	76	75	96	98	97	97	64	65	65	65	34.7	34.4	34.9	34.7
181	1404	29	2	3	49.2	118	123	122	126	66	73	76	75	96	98	97	97	64	65	65	65	34.7	34.4	34.9	35
182	1087	63	1	3	46.7	123	115	131	133	62	61	63	62	99	99	97	99	70	71	77	75	35.8	35.8	36	36
182	1087	63	2	3	46.7	123	118	131	127	62	61	63	62	99	99	97	99	70	71	77	75	35.8	35.8	36	36
183	2088	66	2	3	54.5	132	135	134	135	68	84	66	83	99	99	96	97	86	84	75	73	34.3	34.3	35.4	35.2
184	754	56	1	3	44.1	130	135	134	136	90	86	92	90	99	99	97	96	70	76	59	63	35.7	35.7	35.4	35.3
185	1210	50	2	3	47.7	116	123	115	117	76	78	76	81	98	98	97	99	70	69	66	68	35.4	35.4	35.3	35.3
185	1210	50	2	3	47.7	116	126	126	122	76	78	84	81	98	98	97	99	70	69	66	68	35.4	35.4	35.5	35.3
186	2088	64	2	3	54.5	151	161	156	158	84	89	83	93	99	98	99	98	88	87	109	89	35.1	35.1	35	35
187	754	52	1	3	44.1	104	107	101	105	64	67	70	66	99	98	97	98	79	78	72	70	35.2	35.3	35.5	35.6
188	1210	39	1	3	47.7	117	123	114	116	77	86	80	85	96	97	97	97	69	70	73	73	34.8	34.6	34.3	34.6
188	1210	39	1	3	47.7	117	126	120	123	77	86	80	85	96	97	97	97	69	70	73	73	34.8	34.6	34.3	34.6
189	2189	43	1	3	55.3	99	117	105	118	70	75	66	76	98	99	99	98	74	73	80	81	34.8	34.6	35	35.1
190	709	55	2	3	43.8	130	127	128	118	81	74	73	76	97	99	97	98	70	71	68	35	34.3	34.3	35.6	35.5
191	639	17	2	3	43.2	116	118	128	108	62	64	69	63	99	98	99	99	60	63	65	63	33.6	33.6	35.3	35.1
192	1210	32	2	3	47.7	111	105	115	117	71	69	72	70	97	99	95	97	62	63	69	69	34.8	35	35.4	35.6
192	1210	32	2	3	47.7	111	108	115	118	71	69	72	76	97	99	95	97	62	63	69	69	34.8	35	35.4	35.6
193	1087	20	1	3	46.7	124	120	125	127	77	79	78	78	99	99	96	95	80	79	79	75	34.7	34.6	35.6	35.6
193	1087	20	2	3	46.7	124	123	125	130	77	79	81	78	99	99	96	95	80	79	79	75	34.7	34.6	35.6	35.6
194	414	27	2	3	41.5	128	113	134	133	72	70	74	85	98	99	97	98	69	84	69	70	34.6	34.4	34.9	34.7
194	414	27	1	3	41.5	128	113	117	124	84	79	74	85	98	96	97	98	69	84	69	70	34.6	34.4	34.9	34.7
195	1404	21	2	3	49.2	127	127	130	132	63	68	64	65	99	99	97	98	81	86	74	76	34.6	34.5	34.8	34.7
195	1404	21	1	3	49.2	127	130	130	134	63	68	64	65	99	99	97	98	81	86	74	76	34.6	34.5	34.8	34.9
196	414	34	2	3	41.5	113	122	127	118	62	69	63	70	99	99	98	97	66	66	69	66	33.8	33.9	33.9	34
197	1894	46	2	3	53.0	123	124	121	124	84	84	83	91	98	98	95	94	61	62	69	67	34.8	34.9	35.2	35.5

198	639	23	1	3	43.2	117	119	119	122	60	61	54	66	99	96	97	98	74	74	65	67	34.5	34.7	35.5	35.3
199	1210	63	1	3	47.7	137	133	141	143	87	89	87	88	99	99	94	95	78	76	73	72	35.7	35.7	35.8	35.8
199	1210	63	2	3	47.7	133	136	141	142	87	89	87	88	99	99	94	96	78	76	73	72	35.7	35.7	35.8	35.8
200	1404	57	1	3	49.2	110	116	112	114	82	88	86	88	98	98	95	96	71	75	80	78	35.2	35.1	35.4	35.4
200	1404	57	2	3	49.2	110	119	112	116	82	88	86	88	98	98	95	97	71	75	80	78	35.2	35.1	35.4	35.4
201	639	53	1	3	43.2	125	123	122	127	72	75	71	77	98	96	96	97	92	92	86	85	34.4	34.4	34.7	34.7
202	1894	36	2	3	53.0	127	133	137	135	74	73	81	79	97	98	98	98	72	68	89	85	35	35.1	34.8	34.8
203	1404	59	1	3	49.2	117	122	121	123	71	78	76	83	99	99	97	97	62	61	67	63	34.1	33.9	35.3	35
203	1404	59	2	3	49.2	117	125	134	131	71	78	76	83	99	99	97	97	62	61	67	63	34.1	33.9	35.3	35.5
204	1894	18	2	3	53.0	134	148	152	155	75	77	78	79	98	97	97	97	69	65	69	70	35	35	35.4	35.4
205	367	55	2	3	41.1	131	134	130	134	88	86	80	88	99	99	98	97	73	71	76	74	34.8	34.9	35.5	35.6
206	2088	53	1	3	54.5	123	115	127	129	77	77	77	81	98	96	97	97	90	93	86	88	33.5	33.7	35.2	35.1
207	639	42	2	3	43.2	132	134	129	138	77	71	66	72	98	97	95	96	89	90	83	79	35.3	35.2	35.6	35.4
208	367	59	1	3	41.1	145	128	133	126	74	74	73	69	98	98	99	98	71	71	65	65	35.7	35.6	35.6	35.6
209	639	64	1	3	43.2	108	104	107	115	67	63	74	74	97	98	97	97	80	80	72	70	35.4	35.4	35.8	35.7
210	1404	37	1	3	49.2	175	144	175	177	93	96	91	95	96	96	95	96	87	88	91	93	34.6	34.5	35.6	35.6
211	367	35	2	3	41.1	153	146	147	148	85	97	86	90	97	96	97	97	86	91	87	84	36	36	35.8	35.9
212	367	52	2	3	41.1	114	107	112	106	91	93	94	93	96	98	97	99	78	79	75	75	34.5	34.4	34.8	34.5
213	1404	52	2	3	49.2	122	123	126	133	73	72	77	74	97	97	96	98	87	71	74	74	35.2	35.3	35.7	35.5
214	2189	56	1	3	55.3	117	117	126	118	77	81	81	83	98	99	95	95	65	61	62	63	34.2	34.2	35.4	35.1
215	754	59	2	3	44.1	143	138	150	152	88	92	89	89	97	97	97	97	76	81	64	66	35.2	35.2	35.5	35.7
216	414	35	2	3	41.5	103	116	106	115	58	64	63	66	98	97	95	96	94	94	91	94	35.9	35.8	35.3	35.3
217	1087	63	1	3	46.7	129	129	125	127	70	78	76	83	99	99	97	97	70	72	69	68	34.1	34.4	34.4	34.3
218	2189	43	2	3	55.3	117	125	125	134	77	72	76	73	99	98	96	96	81	83	90	90	34.7	34.4	35.5	35.6
219	709	35	1	3	43.8	120	127	129	129	69	72	72	71	97	96	98	95	78	79	79	80	35.9	35.9	35.7	35.6

جامعة النجاح الوطنية

كلية الدراسات العليا

تأثير شدة الإضاءة على صحة الموظفين في شركات الأدوية

إعداد

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د. محمد سلامة أبو جعفر

قدمت هذه الأطروحة استكمالا لمتطلبات الحصول على درجة الماجستير في الفيزياء بكلية الدراسات العليا في جامعة النجاح الوطنية في نابلس – فلسطين

2014

تأثير شدة الإضاءة على صحة الموظفين في شركات الأدوية

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الملخص

هدفت هذه الدراسة إلى قياس أثر مستوى شدة الإضاءة على ضغط الدم الانقباضي والانبساطي، نسبة الأكسجين في الدم وعدد ضربات القلب في الدقيقة و درجة حرارة الأذن في ثلاثة مصانع للأدوية في محافظة رام الله والبيرة. لقد تم اختيار العاملين من ثلاث شركات أدوية هي شركة بيرزيت لصناعة الأدوية فرع رام الله، شركة دار الشفاء للمستحضرات الطبية، وشركة بيرزيت لصناعة الأدوية فرع بيرزيت. شملت عينة الدراسة 219 موظفا موزعين على الشركات الثلاث وقد تم قياس المتغيرات قبل وبعد يوم العمل تحت شدة إضاءات مختلفة.

أظهرت النتائج وجود علاقة ذات دلالة احصائية بين المتغيرات الصحية و مستوى شدة الإضاءة، حيث كان الارتباط بين كل من ضغط الدم الانقباضي، نسبة الأكسجين في الدم، وعدد ضربات القلب في الدقيقة من جهة و مستوى شدة الإضاءة من جهة أخرى اكبر ما يمكن، بينما كان الارتباط اقل بين درجة حرارة الأذن وشدة الإضاءة.

أظهرت نتائج قياس ضغط ضغط الدم الانقباضي والانبساطي ان هناك زيادة في ضغط الدم كلما زادت شدة الاضاءة ولكنها تبقى ضمن المعدل الطبيعي. كانت قيمة فحص P تساوي 0.000، 0.023 لكل من ضغط الدم الانقباضي والانبساطي على الترتيب. بينما اظهرت النتائج تناقص نسبة الاكسجين في الدم كلما زادت شدة الاضاءة وكانت قيمة فحص P تساوي 0.000 واظهرت درجة الحرارة ارتفاع كلما زادت شدة الاضاءة حيث قيمة فحص $P = 0.002$.