An - Najah National University

Faculty of Graduated Studies

The Effects of Light Intensity on Day and Night Shift Nurses' Health Performance

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Dedication

To the angles disguised in human appearance to guide me through my way ….to the candle that burned itself to light my life to my parents, whose encouragement is constantly rushing to nature my souls, to one whose eyes shine with hope and his smiles with love, to the one who shares my life … to my husband Hassan, to my sisters and brothers, to son of my sisters, to my best friend Maram…..to all of my new family with respect and love.

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الاقرار

أنا الموقع أدناه مقدم الرسالة التي تحمل العنوان:

The Effects of Light Intensity on Day and Night Shift Nurses' Health Performance

اقر بأن ما اشتملت عليه هذه الرسالة، أنما هي نتاج جهدي الخاص، باستثناء ما تمت الإشارة إليه حيثما ورد، وأن هذه الرسالة ككل، أو أي جزء منها لم يقدم من قبل لنيل أي درجة علمية أو بحث علمي لدى أي مؤسسة تعليمية أو بحثية أخرى.

Declaration

This work provided in this thesis, unless other 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	Before Morning
ANOVA	Analysis of Variance
b	Before
dB	Decibel
DBP	Diastolic blood pressure
H_1	Union Hospital
H_2	Specialized Arab Nablus Hospital
H_3	Specialized Nablus Hospital
H_4	Rafidia Governmental Hospital
HPR	Heart Pulse Rate
I	Transmitted Light
I_o	Incident Light
LI	Light Intensity
Log	Logarithmic
Lux	Unit of Illumination
Max	Maximum
Min	Minimum
NICU	Newborn Intensive Care unit
Nm	Nanometer
OSHA	The Occupational Safety and Health Administration
Pa.	Pascal
p.m	After Noon
P – value	Probability
R	Pearson Correlation Coefficient
RMS	Root Mean Square
SBP	Systolic Blood Pressure
S.D	Standard Deviation
SPL	Sound Pressure Level
SPO_2%	Blood Oxygen Saturation
T	Transmitted Coefficient
T(^oC)	Tympanic Temperature
WHO	World Health Organization

The Effects of Light Intensity on Day and Night Shift Nurses' Health Performance

By
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Abstract

This study shed the light on the effect of light intensity on some of the dependent variables, such as blood oxygen saturation (SPO_2%), heart pulse rate (P.R), arterial blood pressure (systolic (SBP), diastolic (DBP)), and tympanic temperature (T) of nurses, in their shift work.

The sample consists of 207 nurses of both genders (104 female, 103 male), with mean age 29 years, and the mean duration of employment 6 years, were randomly chosen as a sample to fulfill the aim meant. This sample was taken from four hospitals in Nablus city. The values of light intensity in all hospital ranged from 220 Lux to 1000 Lux, at the day shift, and from 500 Lux to 1700 Lux, at the night shift. Number of measurements concerning the blood oxygen saturation, heart pulse rate, arterial blood pressure (systolic and diastolic), and tympanic temperature at different light intensities were taken for the selected sample before and an after exposure to light. Strong positive correlation (Pearson Correlation Coefficient) with light intensity was found for all measured variables. The statistical result for the dependent variables (SPO_2%, P.R, SBP, DBP, T) showed that Pearson correlation coefficient (R) between light intensity and the

dependent variables are approximately equal to one, and the Probabilities (P) are < 0.05. 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.

This study shows 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.

Chapter One
Introduction

1.1 Introduction:

Electromagnetic spectrum covers all possible frequencies, from low frequencies (long-wavelength) to gamma radiation at high frequency (short wavelength) Fig. (1.1). These waves can produce different effects on various materials and devices, and therefore different parts of the electromagnetic spectrum have been used for different purposes. The intensity of radiation is a measure of the energy flux, or it can be defined as the total energy per unit area per unit time .(1)

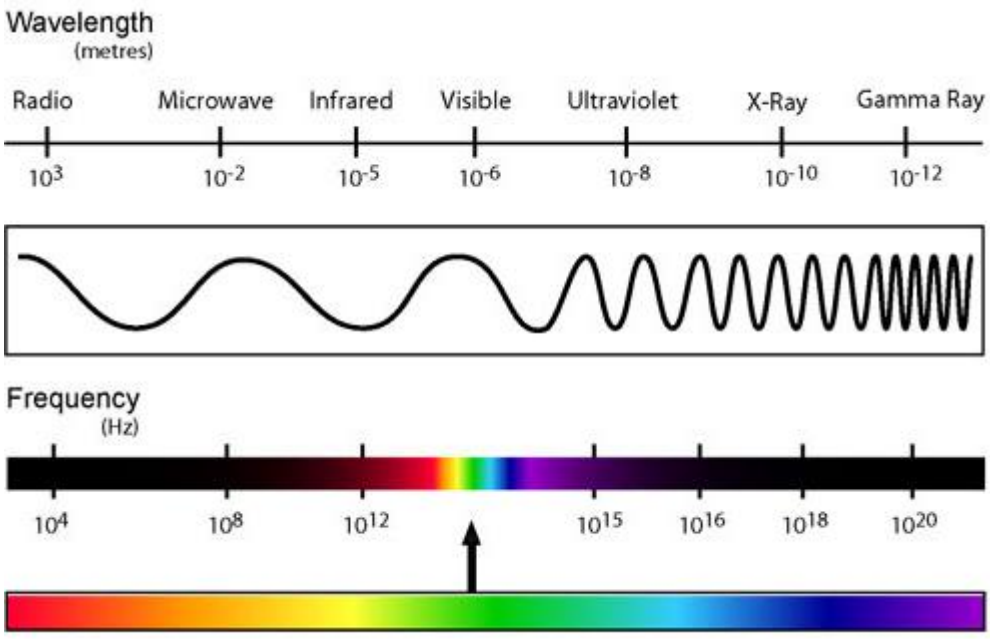

Fig. (1.1): The Electromagnetic Spectrum.

Light can disrupt the body's production of melatonin, which is a hormone produced by pineal gland in brain, melatonin helps in regulating other hormones and maintains the body's circadian rhythm.(2)

Human body needs light, in limited quantities. The suitable amounts depend on several factors including the type of activity or work performed by human, the gender and the work environment.

The Occupational Safety and Health Administration (OSHA) sets the occupational light standards, suitable for human health such as the recommended illumination intensities in lux in different work spaces. As shown in Table (1.1). (3)

Table (1.1): Recommended illumination intensities in lux in different work spaces.

Illumination Lux	Activity
20 – 50	Public areas with dark surroundings
50 – 100	Simple orientation for short visits
100 – 150	Working areas where visual tasks are only occasionally performed
150	Warehouses, Homes, Theaters, Archives
250	Easy Office Work, Classes
500	Normal Office Work, PC Work, Study Library, Groceries, Show Rooms, Laboratories
750	Supermarkets, Mechanical Workshops, Office Landscapes
1,000	Normal Drawing Work, Detailed Mechanical Workshops, Operation Theatres
1500 - 2000	Detailed Drawing Work, Very Detailed Mechanical Works
2000 - 5000	Performance of visual tasks of low contrast and very small size for prolonged periods of time
5000 - 10000	Performance of very prolonged and exacting visual tasks
10000 - 20000	Performance of very special visual tasks of extremely low contrast and small size

Health is defined by the World Health Organization (WHO) as a state of complete physical, mental and social well-being and not merely the absence of disease and infirmity.[(4)] Well-being is defined by Webster's dictionary as "a good or satisfactory condition of existence; a state characterized by health, happiness and prosperity". On the basis of these definitions, light is proposed to have deep influence on health.

Health performance is represented by blood oxygen saturation, blood pressure, heart pulse rate and tympanic temperature.

The normal values of these factors are as follows; (95 - 100%) for blood oxygen saturation, (70) mmHg for diastolic blood pressure and (120) mmHg for systolic blood pressure, (70) beats/min for heart pulse rate and (37℃) for tympanic temperature.[5]

1.2. Previous Studies:

Some studies support the relationship between lighting and human performance, body temperature, human circadian pacemaker, blood oxygen saturation and hormone melatonin.

Hussein [6] in his study showed that shift work, in particular night work can have negative effects on the health, safety, and well-being of workers. His study clearly showed that bright light administration could not reduce anxiety symptoms, somatic symptoms, severe depression and improved social dysfunction significantly during night shift.[6] However, bright light exposure significantly decreased the perception stress and burnout syndrome during night permanent shift. These results suggest that bright light might have provoked changes in perception stress and burnout syndrome of nurses working night permanent shift.[6]

When body is exposed to low intensity light, during night, a hormone called melatonin is produced by pineal gland in the brain.[7] It has been shown that the hormone reduces both blood pressure and body temperature. Therefore,

it has been explored as a treatment option for insomnia, hypertension and cancer.[7]

People are routinely exposed to electrical lighting in the evening hours during work and social activities. A study carried out by Joshua.[8] of Brigham and Women's Hospital shows that exposure to indoor light has a strong suppressive effect on the hormone melatonin. This could have effects on sleep quality and the body's ability to regulate body temperature, blood and glucose level.

A study conducted to explore the effect of night shift on Jordanian nurses at critical care units, using a structured questionnaire describes the effect of night shift among nurses working in critical care units.[9] The results showed that female nurses had a significant difference on sufficient sleep, and interpersonal conflicts.[9] In addition, the results indicated that nurses experience health problems and their work performance were affected by the night shift. The study also indicated that night shift affects critical care nurses well-being.[9]

In young – Mental Hospital, a research showed that real night shift workers can improve nocturnal alertness and daytime sleep when they are exposed to bright light in their work place. These improvements can be maximized by attenuating morning light on the way home.[10]

Another study showed that melatonin levels dropped by 71%, 67%, 44%, 38% and 16% exposing to one hour of light at mid night using different level of light intensities: 3000, 1000, 500, 350 and 200 lux respectively.[11]

A study was performed in China on the effect of light on the physiological parameters of the premature relationship with premature infants' physiological parameters and the heart pulse rate respiration showed that pulse rate increased and the blood oxygen saturation decreased as the intensity of light went up.[12]

Badia in his work,[13]showed that exposure to bright light of 5000 lux elevates body temperature and light exerts a strongly, immediately on physiology and behavior in addition to its powerful influence on circadian organization.[13]

The evening exposure to bright light increases the mean total sleep time more than an hour, so it may be an effective treatment for early morning a wakening insomnia.[14]

Exposure to early morning light can significantly advance the timing of human circadian pacemaker. The resulted response to such light has a non – linear relationship to illuminance and affected plasma melatonin concentrations.[15]

People are exposed to electrical lighting during evening hours in their social activities. A study carried out on nurses working in a newborn intensive care unit (NICU) showed that tympanic temperature was consistently increased when nurses were exposed to bright light during their day and night shifts and their sense of well – being was improved.[16]

Light affects both men and women. However, the effect is different through the level of the absolute values of melatonin plasma levels, whereas after exposing to bright light, the suppression of plasma melatonin was 40%

greater in woman than men. These findings suggest that, there are sex differences in the nocturnal sensitivity of pineal gland to light.[17]

Bright light therapy helps in treatment of non – sad depression and circadian rhythm in dement patients when suffering from delusions or agitation. On the other hand, caution should still be used when using bright light therapy in treating demented patients when agitation develops or increases during bright light therapy.[18]

People who are more satisfied with their lighting rate are happier, more comfortable and satisfied with their environment and their work.[19]

A study conducted by Z. Zamanian in a university hospital, about the effects of bright light on the rhythms in body temperature, plasma melatonin, plasma cortisol and subjective alertness during shift work, indicated that bright light increased cortisol levels and body temperature and improved alertness significantly during night shift. These results demonstrate that photic stimulation in a hospital setting can have a powerful influence on the adjustment of the circadian system.[20]

Artificial light at night disrupts the body's biological clock, significantly reduces the production of a melatonin, and suppresses cancerous growth. People doing overnight work over many years have higher risk of developing cancer, such as breast, prostate or colorectal cancer.[21]

Bright light can influence human psychophysiology instantaneously by inducing endocrine suppression of melatonin, increase cortisol levels, other physiological changes enhancement of core body temperature, and

psychological changes reduction of sleepiness, increase of alertness. Exposure to bright light at night increases heart rate and enhanced core body temperature. It had no significant effect at all on cortisol. The effect of bright light on the psychological variables was time independence, since nighttime and daytime bright light reduced sleepiness.[22]

Light influences the daily rhythm and humans well-being in a physiological, psychological and biological way beside visual photoreceptors, the human eye also contains non visual photoreceptors. Light does not only enable human to see. It also supportes by light perception, the human biological clock system tells the human body when to regulate multiple body functions such as body tempearture, sleep patterns, congnitive performance, mood, well-being and production of hormones melatonin.[23]

It's found that light exposure as brief as a few milliseconds could engender changes in alertness and brain wave activity.[24]

1.3. Objective and aims of this Study

In Palestine, there is a lack of information in the field of the effects of light intensities on the workers' health performance. In this study light intensity will be measured. The light intensity will be compare to the recommended values. The effect of light intensity on blood oxygen saturation, systolic and diastolic blood pressure, pulse rate and tympanic temperature, will be studied.

Chapter Two
Theoretical Background

This chapter consists of three sections including the absorption theory (Sec.2.1) and the effect of light intensity (Sec 2.2) on blood oxygen saturation (Sec 2.2.1), blood pressure (Sec 2.2.2), heart pulse rate (Sec 2.2.3) and tympanic temperature (Sec2.2.4.). Finally, explanation of some basic information about calculation of the sound pressure levels (Sec 2.3).

2.1. Absorption of Light

The absorption of light by human body affect the level of melatonin production. The rhythm and activity of the body depends so much on this level of melatonin.

The intensity of light absorbed by a sample depends on the chemical density of the sample, its thickness, the cross section of absorption, and on the incident light intensity on the sample. Beer[25] in his work observed that, the amount of light absorbed by the sample is proportional to the concentration of dissolved substance through the following relation:

$$I = I_o e^{-\sigma LN} \quad (1)$$

Where I_o and I are the intensity of the incident light and the transmitted light, respectively; σ is the cross section of light absorption by a single particle, N is the density (number of particle per unit volume of absorbing particles and L is the sample thickness. Beer–Lambert law states that there

is a logarithmic dependence between the transmissions T of light through a substance and the product of the absorption coefficient of the substance μ, namely:

$$\ln(T) = -\mu L \tag{2}$$

The transmission coefficient T is the ratio between the transmitted intensity I and the incident intensity I_o.[25]

2.2. The Effect of Intensity of Light on Human Being

Several physiological and health effects of intensity of light on humans were observed.

This study, will focus on four of them, the change of

1. blood oxygen saturation
2. blood pressure
3. heart pulse rate
4. tympanic temperature

2.2.1. Blood Oxygen Saturation

Every living organism requires oxygen for its survival. Health blood oxygen levels are essential for proper functioning of the body. Less amount of oxygen flowing through the blood or oxygen deprivation can lead to organ failure. Lungs are involved in breathing; low oxygen levels suggest lung conditions. Other health conditions can also cause low oxygen levels

in blood. Oxygen saturation is defined as the ratio of oxhemoglobin to the total concentration of hemoglobin in blood**.**

A hemoglobin molecule can carry a maximum of four oxygen molecules. For example, if there are 3000 hemoglobin molecules, these can carry as a maximum of 12000 oxygen molecules. If hemoglobin molecules are carrying 11500 oxygen molecules, then the oxygen saturation level will be $\frac{11500}{12000} \times 100\%$ = 96 %.[26]

The level can be measured with the help of a pulse oximeter attached to a finger. A 95-100% level is considered as normal or healthy while 80-94% oxygen is considered as low blood oxygen or hypoxemia. In children, 97%oxygen level (at least 97% of the blood stream should be oxygen saturated) is considered as normal. Very low level of oxygen (less than 80%) can lead to serious symptoms. As blood that contains oxygen is circulated to the cell and tissues, a healthy level of oxygen in arteries can keep the organs functioning. Hyperoxia is a condition caused by very high level of oxygen in blood. Breathing high concentration of oxygen can lead to hyperoxia which is an equally serious condition. It causes cell death and serious damage, especially to the central nervous system, eye and lungs. [27]

2.2.2. Blood Pressure

Blood pressure is defined as the force of the blood pushing against the walls of the arteries. Each time the heart beats, it pumps blood into the arteries.

During each heartbeat, blood varies from a maximum (systolic) and a minimum (diastolic) pressure. [28]

Blood pressure is measured by the systolic and diastolic values.

The systolic pressure represents the pressure in the arteries as the heart contracts and pumps blood, while the diastolic pressure, represents the pressure in the arteries as the heart relaxes. Normal blood pressure is considered to be 120/70 mm Hg. [29] the value, 120 mmHg is being the systolic pressure while 70 mmHg is being the diastolic pressure. Blood pressure varies during the day. It is lowest when one is sleeping and arises when one is excited, nervous or active. High blood pressure or hypertension means high pressure in arteries.

Blood pressure of 140/90 mmHg or above is considered as high blood pressure. In high blood pressure, the heart works harder, and the chances of a stroke or heart attack are greater.[30]

2.2.3. Heart Pulse Rate:

Heart Pulse rate is the number of times the heart beats in one minute (beat/min). Pulse rates vary from person to person; pulse rate decreases when somebody is at rest and increases while exercising, because the body needs more oxygen-rich blood. The following is the normal heart pulse rate for different ages: [31]

Generally the adults pulse is: 60-100 beats/min.

2.2.4. Tympanic Temperature:

Body temperature is a common vital sign that is used to determine whether a person is sick or in decent health. Those who believe that they or their children are sick may have to take a measure to an internal body temperature to determine the severity of the illness. One common place to check body temperature is in the ear. This is called the "tympanic temperature" as the formal name for the eardrum is the "tympanic membrane". It only takes several seconds to check tympanic temperature. This method has become so common because it is much faster and accurate than obtaining a rectal or oral temperature.[32]

2.3. Sound Pressure Level

Sound pressure level (SPL) or sound level (L_p), measured in decibels, is a logarithmic measure of the energy of particular noise related to a reference noise source of sound pressure P_o = 20 µPa which represents the normal threshold of human hearing at 1000 Hz

The sound pressure level (L_P) is given by the following relation [33]

$$L_p = 20 \log (P/P_0)$$

Where P (µPa) is the measured root – mean – square (rms) sound pressure.

The sound pressure level is measured to normalize the noise effect and to make sure that the only parameter that plays the important role in nurses' activity is light intensity.

Chapter Three
Methodology

3.1 Study Design

Our experimental study which means that we are testing different assumptions by trial and error under conditions constructed and controlled by the researcher. During the experiment, one or more conditions (called independent variables; blood oxygen saturation, heart pulse rate, blood pressure, and tympanic temperature) are allowed to change in an organized manner and the effects of these changes on associated conditions (called dependent variables; intensity of light) were measured, recorded, validated, and analyzed for arriving at a conclusion.

3.2 Population Sample and Sampling Technique

The population sample consists of nurses from four different hospitals in Nablus city. These are Arab Specialist Hospital, Union Hospital, Rafidia Government Hospital, and Specialist Nablus Hospital.

This study was applied to 207 nurses, 103 males and 104 females. They were 21 - 50years old. The nurses chosen had no cardiovascular disease, or hearing impairment. The selected nurses had at least a one year work. Moreover the nurses were asked not to smoke or to eat salty food before taking the measurement, to minimize factors which affect blood pressure and other parameters.

The best value of the sample is calculated according to Cochran formula[34]:

$$n = \frac{Z^2\ P\ q}{\delta^2} \qquad (3)$$

Where, n = best value to select a random sample of nurses in each hospital.

Z = 1.96

(p)(q) = estimate of variance, q = 1 - p, p = 0.9, q = 0.1

δ = acceptable margin of error for proportion being estimated to be 0.055.

Using eq. (3) we get:

n = 114.3

Applying the correction formula of Cochran:

$$m = \frac{n}{1+\frac{n}{N}}, \qquad (4)$$

where, m = correlation sample size that should be used.

N = the actual sample number of nurses that found in each hospital .[34]

The examined nurses, female or male, have no health problems according to their hospital records. Using eq.(4), the number of nurses that should be examined (m) is:

- (71) in Rafidia Government Hospital (H_1).
- (49) in Specialist Nablus Hospital (H_2).
- (53) in Specialist Arab Hospital (H_3).
- (34) in Union Hospital (H_4).

The measurements were done twice; the first was half an hour before the nurses' start their shift, the second measurement was seven hours after they have done their shift.

The nurses were asked to be at rest for half an hour before they started their shift.

Light Intensity and Sound Pressure Level were taken every minute during measurement, starting from (2.00 p.m) till (9.00 p.m) and from (9.00 p.m) till (4.00 a.m).

The measurements, were taken during a period of one weak for each hospital and on the average 5 times for each nurse. The light intensity was measured in the nurse room at reassigned value of 100 lux before the shift starts. The light intensity was measured in various positions in each hospital and averaged to get the value of light intensity during the shift

The values of light intensity in all hospital ranged from 220 Lux to 1000 Lux, at day shift , and from 500 Lux to 1700 Lux, at night shift.

Previous studies show that there is a considerable impact of noise on the blood pressure and other parameters.

Therefore, nurses working in areas of high noise level were not included in the sample to make sure that the effect of noise on the measured parameters is excluded.

The table (3.1) below shows the selected of this sample in these hospitals

Table (3.1): The selected sample in four studied hospitals.

H	Hospital Name	Number of nurses	Female	Male
H_1	Rafedia Governmental Hospital	71	40	31
H_2	Specialized Nablus Hospital	49	25	24
H_3	Specialized Arab Hospital	53	23	30
H_4	Union Hospital	34	16	18

The sample was taken by convenient sampling technique which means that we talk only the available nurses.

3.3. Stages of Study

The stages that have been adopted in this study are as follows:

1. Selecting hospitals in Nablus city
2. Selecting non-smoking nurses and not having health problem.
3. Collecting necessary information concerning the study like; age, employment duration and having other job.
4. Measuring the sound pressure level.
5. Measuring the light intensity of the nurse.
6. The measure parameters are the following:

    1. blood oxygen saturation

    2. blood pressure

    3. heart pulse rate

4. tympanic temperature

7. All measurements for each nurse were repeated; twice at day shift (2 p.m – 9 p.m) before the shift starts and after the shift finishes, twice at night shift (9 p.m – 4 a.m) before the shift starts and after the shift finishes.

3.4. Timetable of the Study

The measurements were carried out in May and June, 2012.

The collected data at hospitals were carried out at day shift (2.00 p.m) before the shift started and in the evening hours at (9.00 p.m) after they finished their shift. In addition the data were carried out at night shift (9.00 p.m) before the shift started and at (4.00 a.m) after the nurses finished their shift work.

3.5. Experimental Apparatus:

- Lux Meter, Fig. (3.1) is a special engineering device which is able to measure brightness. Lux Meter especially measures the intensity of light detected by human eye. This light intensity is different from the energy of light reflected by different objects or produced by light sources. Lux meter is widely used to measure the light levels in different areas such as: hospitals, school, laboratories, passageways, and production areas.

Fig. (3.1): Lux Meter

- Automatic Blood Pressure Monitor micro life AG, Fig. (3.2) Modno. BP 2BHO, Measuring range: (30-280 mmHg) with accuracy ± 2% mm-Hg, and ± 2% for reading heart pulse rate with operating temperature range of +10 °C to +40 °C. This is used for measuring arterial blood pressure (systolic, diastolic and pulse rate). [35]

Fig. (3.2): Automatic Blood Pressure Monitor micro l

- Pulse Oximeter LM-800 Fig. (3.3) with accuracy ± 1%, is used to measure the blood oxygen saturation of each nurse.[36]

Fig. (3.3): Pulse Oximeter LM-800

- The GT-302/GT-302-1 Ear Thermometer Fig.(3.4) that 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 ± 0.01°C.

Fig. (3.4): The GT-302/GT-302-1 Ear Thermometer

- Sound Pressure Level Meter Fig. (3.5), is to measure the noise level in dB. (Quest Technologies U.S.A, Model 2900 type 2) with accuracy of ± 0.5 dB at 25 °C. This device gives the reading with a precision of 0.1dB. [37]

Fig. (3.5): Sound pressure level meter model 2900 type 2.

3.6. Statistical Analysis

The gathered data were digitalized in a database developed with SPSS and Microsoft excel program. The measurements were analyzed statistically as the following:

- Pearson correlation factor (R) and the probability (P) will be used to measure the strength correlation between light intensity levels the dependent variable, and the dependent variables before and after exposure to light. Values with $P < 0.05$ were considered statistically significant.

Chapter Four
Measurements and Results

This chapter includes the measured data and results which conducted on the sample of nurses in the hospitals in Nablus city. The following physical quantities were measured in the hospitals

1. Light intensity level (LI)
2. Sound pressure level (SPL)
3. Systolic (SBP) and diastolic (DBP) blood pressure
4. Heart pulse rate (HPR)
5. Blood oxygen saturation (SPO_2%)
6. Tympanic temperature (T)

4.1 Measuring of light intensity and sound pressure level

The other parameters were taken twice in each shift before starting and after finishing each shift.

The sample was composed of 207 nurses, 104 females and 103 males.

The nurses' ages were between 21 to 50 years and the duration of employment from 1 to 30 year. The results of measurement of light intensity and sound pressure level for all hospital before and after are shown in (Table 4.1).

Table (4.1): Sound pressure level and light intensity for all hospital before and after the nurses start and finish their work

H	Average value of SPL (dB(A)) For two shifts	LI (before) For two shifts (Lux)	Average value of LI at day shift (after) (Lux)	Average value of LI at night shift (after) (Lux)
H_1	50	100	1000	1700
H_2	50	100	700	900
H_3	50	100	500	800
H_4	50	100	220	500

Where H_1 is Rafidia Government Hospital, H_2 Specialist Nablus Hospital, H_3 is Arab Specialist Hospital, H_4 is Union Hospital.

4.2 Measurements of Health Effects of Light Intensity

1. In this section the health parameters which depend on light intensity as blood oxygen saturation, pulse rate, arterial blood pressure (systolic and diastolic) and tympanic temperature are measured.

4.2.1 Blood Oxygen Saturation, Pulse Rate, and Arterial Blood Pressure (systolic and diastolic), and Tympanic Temperature Results

Minimum, maximum, mean, and standard deviation of mean values of duration of employment, age, blood oxygen saturation (SPO_2%), pulse rate (P.R), systolic and diastolic pressure (SBP and DBP), tympanic temperature

before (b) and after (a) exposure to bright light for all selected nurses in all hospitals at shift (2 p.m – 9 p.m) and (9 p.m – 4 a.m) are presented in Tables 4.2 to 4.9.

Table (4.2): Min, Max, mean, and S.D values of studied variables for selected nurses in Rafidia governmental hospital (H_1)at day shift (2 p.m – 9 p.m).

Rafedia Governmental Hospital (H_1)		At average LI (1000 Lux)		
Variables	Min	Max	Mean	S.D
Age (years)	22	55	33	8
Duration of employment (years)	1	25	8	6
SPO_2% (b)	94	100	98	1
SPO_2% (a)	91	97	95	1
SBP mmHg (b)	90	151	124	12
SBP mmHg (a)	115	151	136	9
DBP mmHg (b)	50	95	78	10
DBP mmHg (a)	70	100	86	8
T (^oC) (b)	36.1	37.1	36.7	0.3
T (^oC) (a)	36.7	37.6	37.1	0.2
HPR beats /min (b)	56	110	81	10
HPR beats / min (a)	68	120	90	9

Table (4.3): Min, Max, Mean, and S.D. values of studied variables for selected nurses in Rafidia governmental hospital (H_1) at night shift (9 p.m – 4 a.m)

Rafedia Governmental Hospital (H_1)		At average LI (1700 Lux)			
Variables		**Min**	**Max**	**Mean**	**S.D**
Age (years)		21	58	31	9
Duration of employment (years)		1	25	7	7
SPO_2%	(b)	93	100	97	2
SPO_2%	(a)	92	98	94	1
SBP mmHg	(b)	90	150	127	13
SBP mmHg	(a)	105	151	139	10
DBP mmHg	(b)	52	93	81	10
DBP mmHg	(a)	63	96	89	9
T (^{o}C)	(b)	36.0	37.6	36.8	0.4
T (^{o}C)	(a)	36.2	37.6	37.4	0.3
HPR beats /min	(b)	63	112	83	12
HPR beats / min	(a)	67	120	93	13

Table (4.4): Min, Max, Mean, and S.D. values of studied variables for selected nurses in Specialized Nablus hospital (H_2) at day shift (2 p.m – 9 p.m)

Specialized Nablus Hospital (H_2)			At average LI (700Lux)	
Variables	**Min**	**Max**	**Mean**	**S.D**
Age (years)	21	58	31	9
Duration of employment (years)	1	25	7	7
SPO_2% (b)	95	99	98	1
SPO_2% (a)	93	98	96	1
SBP mmHg (b)	90	143	122	12
SBP mmHg (a)	105	150	132	9
DBP mmHg (b)	52	90	77	9
DBP mmHg (a)	63	93	83	8
T (^oC) (b)	36.0	37.0	36.7	0.4
T (^oC) (a)	36.2	37.6	37.1	0.3
HPR beats /min (b)	60	112	79	13
HPR beats / min (a)	63	120	86	13

Table (4.5): Min, Max, Mean, and S.D. values of studied variables for selected nurses in Specialized Nablus Hospital (H_2) at night shift (9 p.m – 4 a.m).

Specialized Nablus Hospital (H_2)		At average LI (900 Lux)		
Variables	**Min**	**Max**	**Mean**	**S.D**
Age (years)	22	55	33	8
Duration of employment (years)	1	25	8	6
SPO_2% (b)	92	99	97	2
SPO_2% (a)	90	98	95	1
SBP mmHg (b)	90	151	124	11
SBP mmHg (a)	112	152	135	9
DBP mmHg (b)	53	95	79	10
DBP mmHg (a)	70	99	87	8
T (^oC) (b)	36.1	37.3	36.8	0.3
T (^oC) (a)	36.7	37.9	37.2	0.2
HPR beats /min (b)	60	115	82	10
HPR beats / min (a)	70	120	89	10

Table (4.6): Min, Max, Mean, and S.D. values of studied variables for selected nurses in Specialized Nablus Arab Hospital (H_3) at day shift (2 p.m – 9 p.m)

Specialized Arab Hospital Nablus (H_3)		At average LI (500Lux)		
Variables	**Min**	**Max**	**Mean**	**S.D**
Age (years)	20	60	26	6
Duration of employment (years)	1	25	4	4
SPO_2% (b)	95	100	98	1
SPO_2% (a)	94	99	96	1
SBP mmHg (b)	90	154	116	13
SBP mmHg (a)	108	160	124	11
DBP mmHg (b)	65	94	74	7
DBP mmHg (a)	70	102	80	8
T (^oC) (b)	35.3	37.1	36.5	0.4
T (^oC) (a)	36.0	37.2	36.9	0.3
HPR beats /min (b)	52	110	79	11
HPR beats / min (a)	66	112	85	11

Table (4.7): Min, Max, Mean, and S.D. Values of studied variables for selected nurses in specialized Arab Nablus hospital (H_3) at night shift (9 p.m – 4 a.m) .

Specialized Arab Hospital Nablus (H_3) At average LI (800 Lux)				
Variables	**Min**	**Max**	**Mean**	**S.D**
Age (years)	20	60	26	6
SPO_2% (b)	1	25	4	4
SPO_2% (a)	95	99	97	1
SBP mmHg (b)	93	97	95	1
SBP mmHg (a)	90	154	119	13
DBP mmHg (b)	110	158	127	10
DBP mmHg (a)	65	102	75	9
T (^oC) (b)	72	104	83	9
T (^oC) (a)	35.3	37.1	36.7	0.4
HPR beats /min (b)	35.7	37.2	37	0.3
HPR beats / min (a)	52	110	81	12
HPR beats / min (a)	60	120	88	12

Table (4.8): Min, Max, Mean, and S.D. values of studied variables for selected nurses in Union Hospital (H_4) at day shift (2 p.m – 9 p.m) .

Union Hospital (H_4)		At average LI (220 Lux)			
Variables		**Min**	**Max**	**Mean**	**S.D**
Age (years)		21	50	31	8
Duration of employment (years)		1	25	7	6
SPO_2%	(b)	95	100	98	1
SPO_2%	(a)	93	98	96	1
SBP mmHg	(b)	110	141	116	10
SBP mmHg	(a)	112	145	122	9
DBP mmHg	(b)	55	89	72	8
DBP mmHg	(a)	66	93	78	7
T (^oC)	(b)	35.5	37.1	36.2	0.4
T (^oC)	(a)	36.0	37.2	36.3	0.3
HPR beats /min	(b)	59	104	75	12
HPR beats / min	(a)	65	110	80	13

Table (4.9): Min, Max, Mean, and S.D. values of studied variables for selected nurses in Union hospital (H_4) at night shift (9 p.m – 4 a.m).

Union Hospital (H_4)		At average LI (500 Lux)			
Variables		**Min**	**Max**	**Mean**	**S.D**
Age (years)		21	50	31	8
Duration of employment (years)		1	25	7	6
SPO_2%	(b)	93	100	97	2
SPO_2%	(a)	91	98	95	1
SBP mmHg	(b)	110	145	119	10
SBP mmHg	(a)	112	150	126	9
DBP mmHg	(b)	65	90	75	7
DBP mmHg	(a)	70	95	82	7
T (^oC)	(b)	35.5	37.2	36.5	0.4
T (^oC)	(a)	36.0	37.3	36.7	0.3
HPR beats /min	(b)	59	110	77	14
HPR beats / min	(a)	65	112	84	14

Tables (4.10 – 4.17) represent the minimum, maximum, mean, and standard deviation of mean values of duration of employment, age, blood oxygen saturation (SPO_2%), pulse rate (P.R), systolic and diastolic pressure (SBP and DBP), tympanic temperature before (b) and after (a) exposure to bright

light for male nurses in all hospitals at day shift (2 p.m – 9 p.m) and night shift (9 p.m – 4 a.m).

Table (4.10): Min, Max, Mean, and S.D. values of studied variables for male nurses in Rafedia Governmental hospital (H_1) at day shift (2 p.m – 9 p.m).

Rafedia Governmental Hospital (H_1)		At average LI (1000 Lux)			
Variables		**Min**	**Max**	**Mean**	**S.D**
Age (years)		22	48	31	7
Duration of employment (years)		1	20	6	5
SPO_2%	(b)	94	99	98	1
SPO_2%	(a)	91	97	95	1
SBP mmHg	(b)	100	151	118	13
SBP mmHg	(a)	115	151	130	10
DBP mmHg	(b)	58	94	72	11
DBP mmHg	(a)	70	98	82	8
T (^{o}C)	(b)	36.1	37.0	36.8	0.3
T (^{o}C)	(a)	36.7	37.3	37.4	0.2
HPR beats /min	(b)	56	110	77	12
HPR beats / min	(a)	68	120	88	11

Table (4.11): Min, Max, Mean, and S.D. values of studied variables for male nurses in Specialized Nablus hospital (H_2) at day shift (2 p.m – 9 p.m).

Specialized Nablus Hospital (H_2)		At average LI (700 Lux)			
Variables		**Min**	**Max**	**Mean**	**S.D**
Age (years)		21	52	29	8
Duration of employment (years)		1	25	6	6
SPO_2%	(b)	96	99	98	1
SPO_2%	(a)	93	98	96	1
SBP mmHg	(b)	90	130	113	10
SBP mmHg	(a)	105	135	123	8
DBP mmHg	(b)	60	90	71	8
DBP mmHg	(a)	63	93	77	8
T (^oC)	(b)	36.0	37	37	0.4
T (^oC)	(a)	36.2	37	36.9	0.3
HPR beats /min	(b)	60	112	82	12
HPR beats / min	(a)	63	120	87	13

Table (4.12): Min, Max, Mean, and S.D. values of studied variables for male nurses in specialized Arab hospital Nablus (H_3) at day shift (2 p.m – 9 p.m).

Specialized Arab Hospital Nablus (H_3) At average LI (500 Lux)				
Variables	**Min**	**Max**	**Mean**	**S.D**
Age (years)	20	60	27	7
Duration of employment (years)	1	25	4	5
SPO_2% (b)	96	99	98	1
SPO_2% (a)	94	98	95	1
SBP mmHg (b)	99	154	127	14
SBP mmHg (a)	109	160	134	13
DBP mmHg (b)	68	94	79	8
DBP mmHg (a)	73	99	84	7
T (^oC) (b)	35.3	36.9	36.4	0.4
T (^oC) (a)	36.0	37.0	36.7	0.3
HPR beats /min (b)	52	110	80	17
HPR beats / min (a)	66	112	85	12

Table (4.13): Min, Max, Mean, and S.D. values of studied variables for male nurses in Union hospital (H_4) at day shift (2 p.m – 9 p.m).

Union Hospital (H_4)	At average LI (220 lux)			
Variables	**Min**	**Max**	**Mean**	**S.D**
Age (years)	21	50	31	10
Duration of employment (years)	1	25	7	8
SPO_2% (b)	96	100	98	1
SPO_2% (a)	93	98	97	1
SBP mmHg (b)	110	141	121	9
SBP mmHg (a)	112	145	126	10
DBP mmHg (b)	55	85	74	8
DBP mmHg (a)	66	90	79	7
T (^oC) (b)	36.2	37.0	36.7	0.3
T (^oC) (a)	36.5	37.2	36.9	0.2
HPR beats /min (b)	59	104	80	13
HPR beats / min (a)	65	110	85	13

Table (4.14): Min, Max, Mean, and S.D. values of studied variables for male nurses in Rafidia governmental hospital (H_1) at night shift (9 p.m – 4 a.m).

Rafedia Governmental Hospital (H_1) At average LI (1700 Lux)				
Variables	**Min**	**Max**	**Mean**	**S.D**
Age (years)	22	48	31	7
Duration of employment (years)	1	20	6	5
SPO_2% (b)	92	99	97	1
SPO_2% (a)	90	96	93	1
SBP mmHg (b)	109	151	121	12
SBP mmHg (a)	120	152	132	9
DBP mmHg (b)	58	94	74	10
DBP mmHg (a)	70	99	84	8
T (^oC) (b)	36.1	37.2	36.8	0.3
T (^oC) (a)	36.7	37.9	37.5	0.3
HPR beats /min (b)	60	115	79	13
HPR beats / min (a)	70	120	90	12

Table (4.15): Min, Max, Mean, and S.D. values of studied variables for male nurses in Specialized Nablus hospital (H_2) at night shift (9 p.m – 4 a.m).

Specialized Nablus Hospital (H_2)	At average LI (900 Lux)			
Variables	**Min**	**Max**	**Mean**	**S.D**
Age (years)	21	52	29	8
Duration of employment (years)	1	25	6	6
SPO_2% (b)	94	99	97	1
SPO_2% (a)	93	98	95	1
SBP mmHg (b)	90	135	117	11
SBP mmHg (a)	105	140	126	8
DBP mmHg (b)	60	93	73	9
DBP mmHg (a)	63	96	79	9
T (^oC) (b)	36.0	37.2	36.7	0.4
T (^oC) (a)	36.2	37.6	37.0	0.4
HPR beats /min (b)	63	112	83	11
HPR beats / min (a)	67	120	89	13

Table (4.16): Min, Max, Mean, and S.D. values of studied variables for male nurses in specialized Arab Nablus hospital (H_3) at night shift (9 p.m – 4 a.m).

Specialized Arab Hospital Nablus (H_3)		At average LI (800 Lux)			
Variables		**Min**	**Max**	**Mean**	**S.D**
Age (years)		20	60	27	7
Duration of employment (years)		1	25	4	5
SPO_2%	(b)	95	99	97	1
SPO_2%	(a)	93	97	95	1
SBP mmHg	(b)	99	154	130	14
SBP mmHg	(a)	110	158	136	12
DBP mmHg	(b)	68	96	81	9
DBP mmHg	(a)	74	100	87	8
T (^oC)	(b)	35.3	37.0	36.4	0.4
T (^oC)	(a)	35.7	37.1	36.8	0.3
HPR beats /min	(b)	52	110	82	14
HPR beats / min	(a)	60	120	88	14

Table (4.17): Min, Max, Mean, and S.D. values of studied variables for male nurses in Union hospital (H_4) at night shift (9 p.m – 4 a.m) .

Union Hospital (H_4)		At average LI(500 Lux)			
Variables		**Min**	**Max**	**Mean**	**S.D**
Age (years)		21	50	31	10
Duration of employment (years)		1	25	7	8
SPO_2%	(b)	93	100	97	2
SPO_2%	(a)	91	97	95	2
SBP mmHg	(b)	110	145	123	10
SBP mmHg	(a)	112	150	129	10
DBP mmHg	(b)	65	87	77	7
DBP mmHg	(a)	70	90	82	7
T (^oC)	(b)	36.2	37.2	36.8	0.3
T (^oC)	(a)	36.5	37.3	37.1	0.2
HPR beats /min	(b)	59	110	83	14
HPR beats / min	(a)	65	111	88	13

Tables (4.18 – 4.25) represent the same variables for female nurses in all hospitals at day shift (2 p.m – 9 p.m) and night shift (9 p.m – 4 a.m).

Table (4.18): Min, Max, Mean, and S.D. values of studied variables for female nurses in Rafidia governmental hospital (H_1) at day shift (2 p.m – 9 p.m) .

Rafedia Governmental Hospital (H_1) At average LI(1000 Lux)				
Variables	**Min**	**Max**	**Mean**	**S.D**
Age (years)	24	55	34	9
Duration of employment (years)	1	25	9	7
SPO_2% (b)	95	100	98	1
SPO_2% (a)	93	97	94	1
SBP mmHg (b)	90	140	114	11
SBP mmHg (a)	115	150	127	8
DBP mmHg (b)	50	95	73	10
DBP mmHg (a)	70	100	84	7
T (^oC) (b)	36.2	37.1	36.8	0.2
T (^oC) (a)	36.9	37.6	37.4	0.2
HPR beats /min (b)	63	92	74	8
HPR beats / min (a)	75	99	86	7

Table (4.19): Min, Max, Mean, and S.D. values of studied variables for female nurses in Specialized Nablus hospital (H_2) at day shift (2 p.m – 9 p.m).

Specialized Nablus Hospital (H_2) At average LI (700 Lux)				
Variables	**Min**	**Max**	**Mean**	**S.D**
Age (years)	23	58	33	9
Duration of employment (years)	1	25	9	7
SPO_2% (b)	95	99	97	1
SPO_2% (a)	93	97	94	1
SBP mmHg (b)	90	143	119	13
SBP mmHg (a)	110	150	130	10
DBP mmHg (b)	52	89	76	9
DBP mmHg (a)	65	92	82	8
T (^oC) (b)	36.1	37.0	36.7	0.3
T (^oC) (a)	36.5	37.6	37.0	0.3
HPR beats /min (b)	60	112	81	15
HPR beats / min (a)	69	103	88	14

Table (4.20): Min, Max, Mean, and S.D. values of studied variables for female nurses in specialized Arab Nablus hospital (H_3) at day shift (2 p.m – 9 p.m) .

Specialized Arab Hospital Nablus (H_3) At average LI (500 Lux)				
Variables	**Min**	**Max**	**Mean**	**S.D**
Age (years)	20	33	24	3
Duration of employment (years)	1	12	4	3
SPO_2% (b)	95	100	98	1
SPO_2% (a)	94	99	95	1
SBP mmHg (b)	90	130	120	10
SBP mmHg (a)	108	136	127	7
DBP mmHg (b)	65	89	77	6
DBP mmHg (a)	70	102	83	9
T (^oC) (b)	35.9	37.1	37	0.3
T (^oC) (a)	36.0	37.2	37.3	0.3
HPR beats /min (b)	63	89	77	7
HPR beats / min (a)	68	98	83	8

Table (4.21): Min, Max, Mean, and S.D. values of studied variables for female nurses in Union hospital (H_4) at day shift (2 p.m – 9 p.m).

Union Hospital (H_4)		At average LI (220 Lux)			
Variables		**Min**	**Max**	**Mean**	**S.D**
Age (years)		22	45	31	7
Duration of employment (years)		1	15	6	4
SPO_2%	(b)	95	99	97	1
SPO_2%	(a)	93	98	96	2
SBP mmHg	(b)	110	140	124	10
SBP mmHg	(a)	120	145	131	8
DBP mmHg	(b)	68	89	80	7
DBP mmHg	(a)	70	93	86	7
T (^oC)	(b)	35.5	37.1	36.6	0.5
T (^oC)	(a)	36.0	37.2	36.6	0.3
HPR beats /min	(b)	64	94	78	11
HPR beats / min	(a)	70	101	84	13

Table (4.22): Min, Max, Mean, and S.D. values of studied variables for female nurses in Rafidia governmental hospital (H_1) at night shift (9 p.m – 4 a.m).

Rafedia Governmental Hospital (H_1) At average LI (1700 Lux)				
Variables	Min	Max	Mean	S.D
Age (years)	24	55	34	9
Duration of employment (years)	1	25	9	7
SPO_2% (b)	93	99	97	2
SPO_2% (a)	91	98	93	1
SBP mmHg (b)	90	143	118	10
SBP mmHg (a)	112	151	131	9
DBP mmHg (b)	53	95	75	10
DBP mmHg (a)	74	99	87	7
T (^oC) (b)	36.4	37.3	36.9	0.2
T (^oC) (a)	37.0	37.6	37.6	0.2
HPR beats /min (b)	63	92	76	8
HPR beats / min (a)	75	102	88	8

Table (4.23): Min, Max, Mean, and S.D. values of studied variables for female nurses in Specialized Nablus hospital (H_2) at night shift (9 p.m – 4 a.m).

Specialized Nablus Hospital (H_2)		At average LI (900 Lux)			
Variables		**Min**	**Max**	**Mean**	**S.D**
Age (years)		23	58	33	9
Duration of employment (years)		1	25	9	7
SPO_2%	(b)	93	100	97	2
SPO_2%	(a)	92	96	95	1
SBP mmHg	(b)	90	150	121	14
SBP mmHg	(a)	110	151	129	10
DBP mmHg	(b)	52	90	77	10
DBP mmHg	(a)	65	93	81	8
T (^oC)	(b)	36.1	37.6	36.8	0.4
T (^oC)	(a)	36.5	37.6	37.1	0.3
HPR beats /min	(b)	63	103	83	14
HPR beats / min	(a)	70	104	88	13

Table (4.24): Min, Max, Mean, and S.D. values of studied variables for female nurses in specialized Arab Nablus hospital (H_3) at night shift (9 p.m – 4 a.m).

Specialized Arab Hospital Nablus (H_3) At average LI (800 Lux)				
Variables	**Mini**	**Max**	**Mean**	**S.D**
Age (years)	20	33	24	3
Duration of employment (years)	1	12	4	3
SPO_2% (b)	95	99	97	1
SPO_2% (a)	93	97	95	1
SBP mmHg (b)	90	135	123	11
SBP mmHg (a)	115	138	130	6
DBP mmHg (b)	65	102	81	10
DBP mmHg (a)	72	104	85	9
T (^oC) (b)	35.9	37.1	36.6	0.4
T (^oC) (a)	36.2	37.2	36.8	0.3
HPR beats /min (b)	63	98	80	8
HPR beats / min (a)	70	100	87	9

Table (4.25): Min, Max, Mean, and S.D. values of studied variables for female nurses in Union hospital (H_4) at night shift (9 p.m – 4 a.m).

Union Hospital (H_4)	At average LI (500 Lux)			
Variables	**Min**	**Max**	**Mean**	**S.D**
Age (years)	22	45	31	7
Duration of employment (years)	1	15	6	4
SPO_2% (b)	94	99	97	1
SPO_2% (a)	93	98	95	2
SBP mmHg (b)	110	140	126	9
SBP mmHg (a)	124	145	132	7
DBP mmHg (b)	70	90	81	7
DBP mmHg (a)	75	95	86	6
T (^oC) (b)	35.5	37.2	36.7	0.5
T (^oC) (a)	36.0	37.3	36.9	0.4
HPR beats /min (b)	64	101	82	13
HPR beats / min (a)	70	112	88	15

Finally, The net change of blood oxygen saturation, pulse rate, systolic and diastolic pressure, and tympanic temperature before and after exposure to bright light for all nurses, male, and female, at shift day (2 p.m – 9 p.m) and for night shift (9 p.m – 4 a.m) are calculated and shown in (Tables 4.26 - 4.31).

Table (4.26): Net change of blood oxygen saturation, pulse rate, and blood pressure (systolic and diastolic) before and after exposure to light intensity for all nurses at day shift (2 p.m – 9 p.m).

Differences between means	**H_1**	**H_2**	**H_3**	**H_4**
SPO_2%	2.95	2.30	2.21	1.64
S.B.P mmHg	11.6	9.49	7.62	6.02
D.B.P mmHg	7.92	6.64	6.10	5.96
T(^{0}C)	0.43	0.40	0.33	0.10
H.P.R beats/min	9.16	6.63	6.00	5.16

Table (4.27): Net change of blood oxygen saturation, pulse rate, and blood pressure (systolic and diastolic) before and after exposure to light intensity for all nurses at night shift (9 p.m – 4 a.m).

Differences between means	H_1	H_2	H_3	H_4
SPO_2%	3.00	2.42	2.30	1.81
S.B.P mmHg	12.1	10.7	8.11	7.32
D.B.P mmHg	8.01	7.77	7.60	6.85
T(^{0}C)	0.50	0.42	0.36	0.21
H.P.R beats/min	9.90	7.88	7.00	6.85

Table (4.28): Net change of blood oxygen saturation, pulse rate, and blood pressure (systolic and diastolic) before and after exposure to light intensity for male nurses at day shift (2 p.m – 9 p.m).

Differences between means	H_1	H_2	H_3	H_4
SPO_2%	3.32	2.40	2.20	1.44
S.B.P mmHg	11.4	9.12	6.50	5.00
D.B.P mmHg	10.4	5.50	5.17	5.00
T(^{0}C)	0.62	0.30	0.28	0.23
H.P.R beats/min	11.5	5.56	5.23	5.16

Table (4.29): Net change of blood oxygen saturation, pulse rate, and blood pressure (systolic and diastolic) before and after exposure to light intensity for male nurses at night shift (9 p.m – 4 a.m) .

Differences between means	**H_1**	**H_2**	**H_3**	**H_4**
SPO_2%	3.47	2.50	2.45	2.12
S.B.P mmHg	11.4	9.29	6.70	6.12
D.B.P mmHg	10.4	5.88	5.94	5.55
T(^{0}C)	0.69	0.37	0.32	0.29
H.P.R beats/min	11.6	5.54	6.10	5.62

Table (4.30): Net change of blood oxygen saturation, pulse rate, and blood pressure (systolic and diastolic) before and after exposure to light intensity for female nurses at day shift (2 p.m – 9 p.m).

Differences between means	**H_1**	**H_2**	**H_3**	**H_4**
SPO_2%	4.17	3.02	2.91	1.75
S.B.P mmHg	12.3	10.9	6.48	6.75
D.B.P mmHg	11.8	5.94	5.70	5.93
T(^{0}C)	0.66	0.31	0.29	0.28
H.P.R beats/min	11.6	6.68	6.13	6.00

Table 4.31: Net change of blood oxygen saturation, pulse rate, and blood pressure (systolic and diastolic) before and after exposure to light intensity for female nurses at night shift (9 p.m – 4 a.m).

Differences between means	H_1	H_2	H_3	H_4
SPO_2%	4.28	3.16	3.00	1.88
S.B.P mmHg	13.3	10.6	7.13	6.82
D.B.P mmHg	11.8	6.24	6.48	6.06
T(^{0}C)	0.70	0.35	0.30	0.29
H.P.R beats/min	11.6	6.75	6.38	6.25

4.3 Data Analysis of Result of Light Intensity Dependent

Health Parameters in the Selected Hospitals

Results of light intensity, blood oxygen saturation, pulse rate, blood pressure (systolic and diastolic pressure), and tympanic temperature showed that there is shifting of these measurements after exposure to different intensities of light. It is found that there is a strong positive correlation (Pearson correlation coefficient) between light intensity, as independent variable and blood oxygen saturation, pulse rate, blood pressure (systolic and diastolic pressure), and tympanic temperature at different intensities of light as dependent variables. All of these relationships are presented in Table 4.34 for day shift (2 p.m – 9 p.m), and in Table 4.35 for night shift (9 p.m – 4 a.m).

Table 4.32: Paired sample correlation of all studied variables before (b) and after (a) exposure to light intensities for all selected nurses in all hospitals at day shift (2 p.m – 9 p.m).

paired variables		Correlation Pearson	Sig-P- value
LI (Lux) and SPO_2 %	(b)	0.957	0.043
LI (Lux) and SPO_2 %	(a)	0.980	0.020
LI (Lux) and SBP mmHg	(a)	0.989	0.011
LI (Lux) and SBP mmHg	(b)	0.927	0.073
LI (Lux) and DBP mmHg	(b)	0.981	0.019
LI (Lux) and DBP mmHg	(a)	0.985	0.015
LI (Lux) and T (^{o}C)	(b)	0.569	0.404
LI (Lux) and T (^{o}C)	(a)	0.990	0.010
LI (Lux) and HPR beats/min	(b)	0.966	0.034
LI (Lux) and HPR beats/min	(a)	0.988	0.012

Table 4.33: Paired sample correlation of all studied variables before (b) and after (a) exposure to light intensities for all selected nurses in all hospitals at night shift (9 p.m – 4 a.m).

paired variables		Correlation Pearson	Sig-P- value
LI (Lux) and SPO_2 %	(b)	0.915	0.084
LI (Lux) and SPO_2 %	(a)	0.895	0.105
LI (Lux) and SBP mmHg	(a)	0.901	0.099
LI (Lux) and SBP mmHg	(b)	0.848	0.152
LI (Lux) and DBP mmHg	(b)	0.915	0.085
LI (Lux) and DBP mmHg	(a)	0.619	0.381
LI (Lux) and T (^{o}C)	(b)	0.841	0.159
LI (Lux) and T (^{o}C)	(a)	0.886	0.114
LI (Lux) and HPR beats/min	(b)	0.754	0.246
LI (Lux) and HPR beats/min	(a)	0.815	0.185

Figs (4.1 – 4.5) display relationships between mean values of blood oxygen saturation, pulse rate, blood pressure (systolic and diastolic pressure), and tympanic temperature, and intensity of light in each hospital in day shift (2 p.m – 9 p.m) before (b) and after (a) exposure to light intensity.

Where H_1 is Rafidia Governmental Hospital, H_2 is specialized Nablus hospital, H_3 is specialized Arab Nablus Hospital, H_4 is Union Hospital.

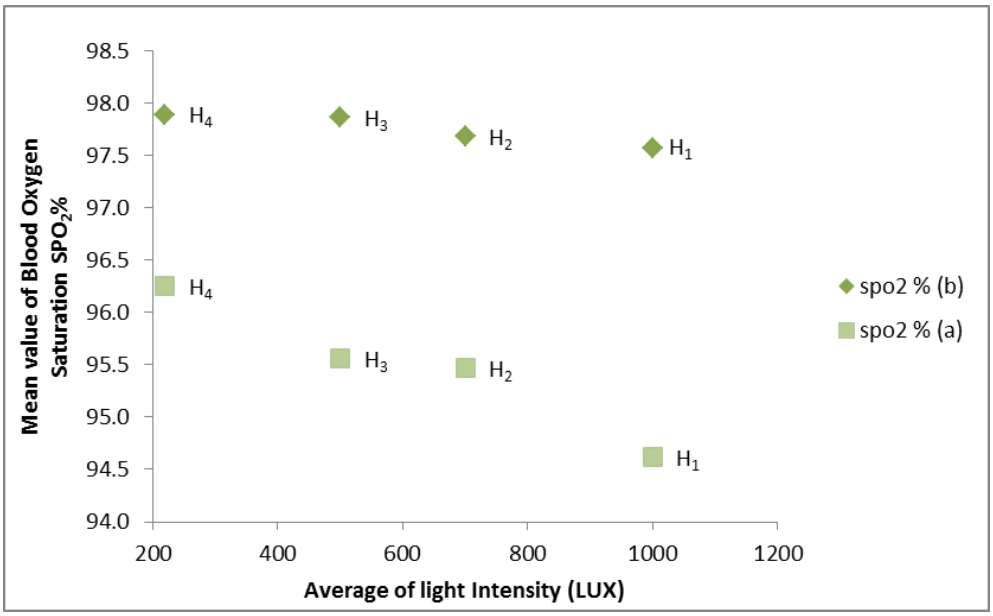

Fig. (4.1): Mean values of blood oxygen saturation (SPO_2%) of nurses as a function of light intensity in day shift before (b) and after (a) exposure to light intensity.

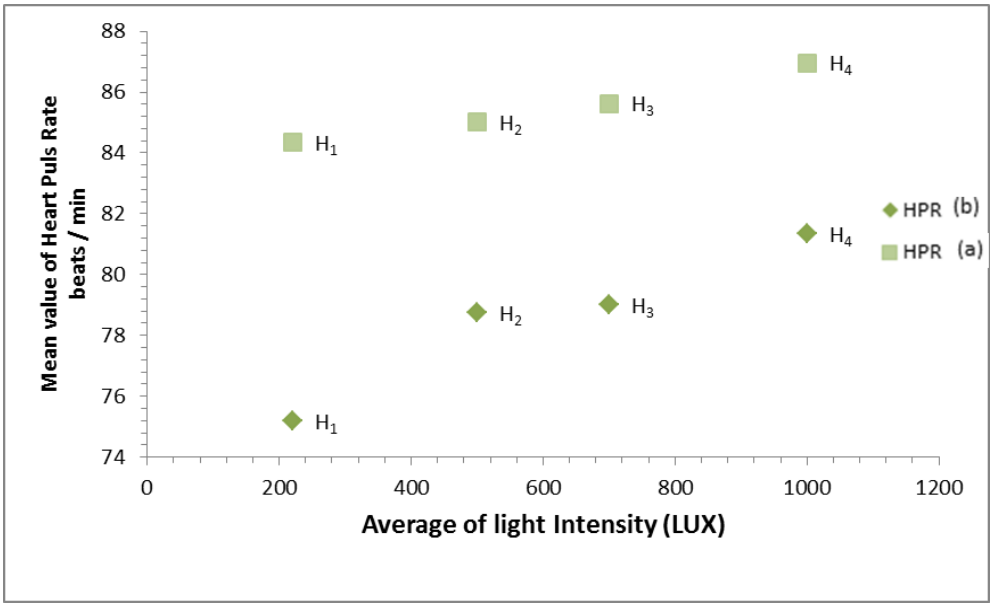

Fig. (4.2): Mean values of heart pulse rate (HPR) of nurses as a function of light intensity in day shift before (b) and after (a) exposure to light intensity.

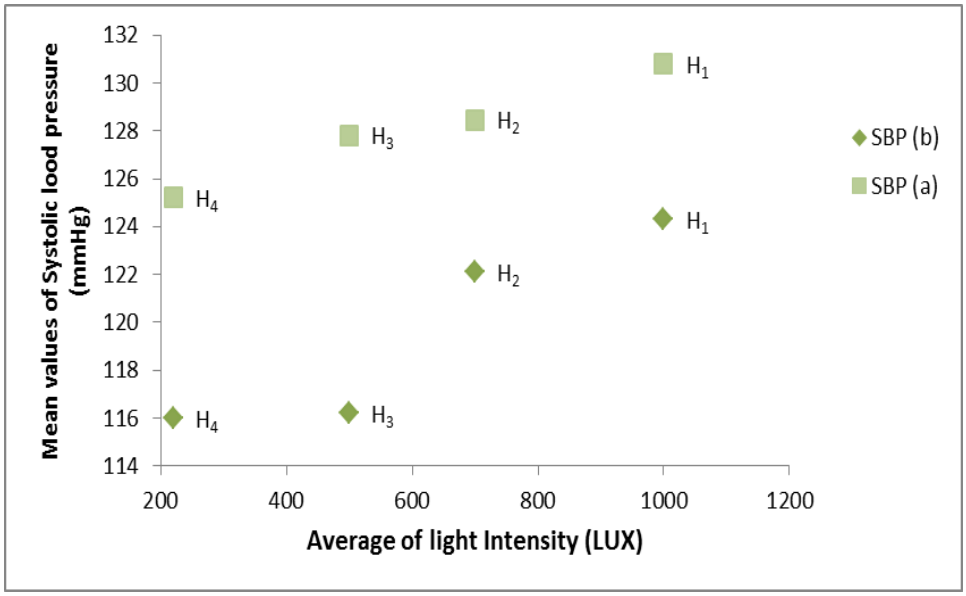

Fig. (4.3): Mean values of systolic blood pressure (SBP) of nurses as a function of light intensity in day shift before (b) and after (a) exposure to light intensity.

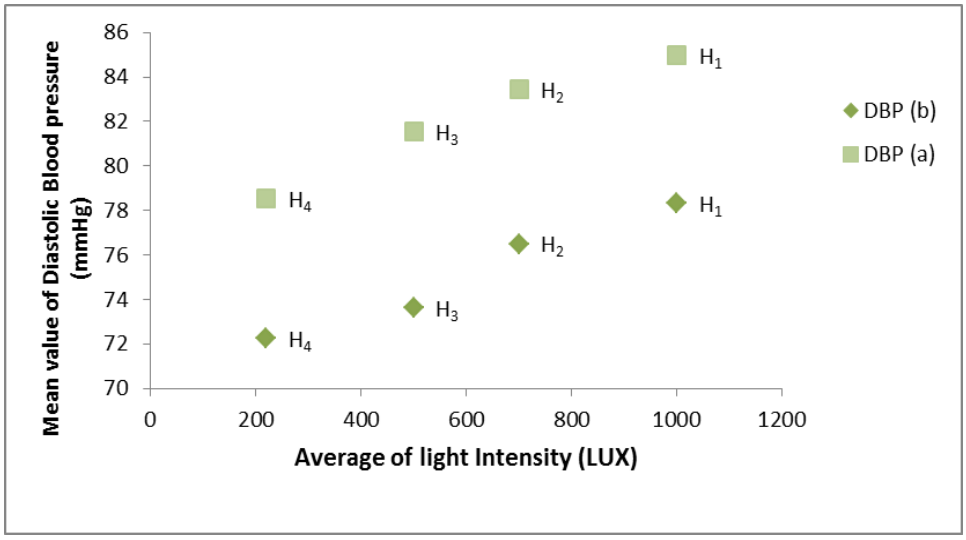

Fig. (4.4): Mean values of diastolic blood pressure (SBP) of nurses as a function of light intensity in day shift before (b) and after (a) exposure to light intensity.

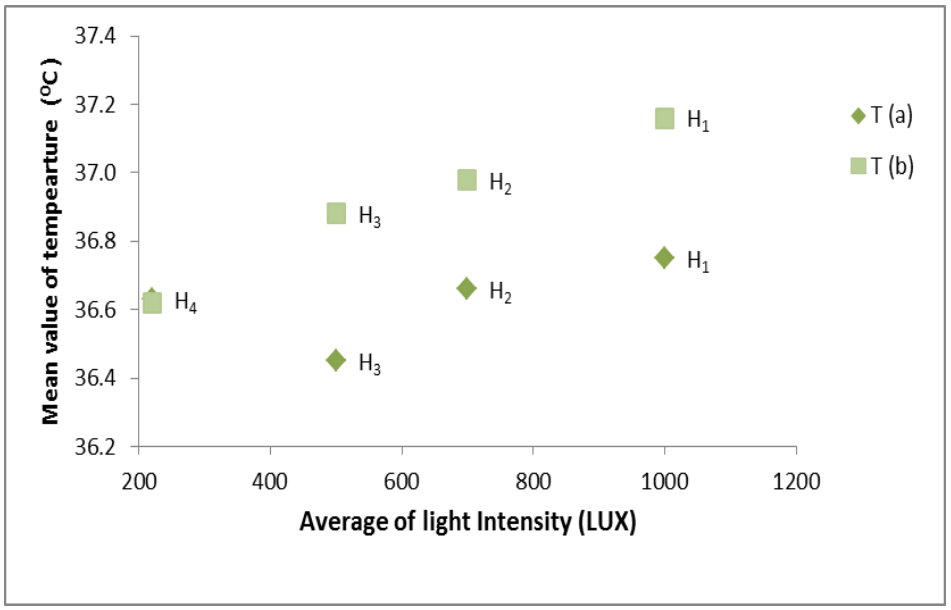

Fig. (4.5): Mean values of temperature (T) of nurses as a function of light intensity in day shift before (b) and after (a) exposure to light intensity.

Figs (4.6 – 4.10) display relationships between mean values of blood oxygen saturation, pulse rate, blood pressure (systolic and diastolic pressure), and tympanic temperature, and intensity of light in night shift before (b) and after (a) exposure to light intensity.

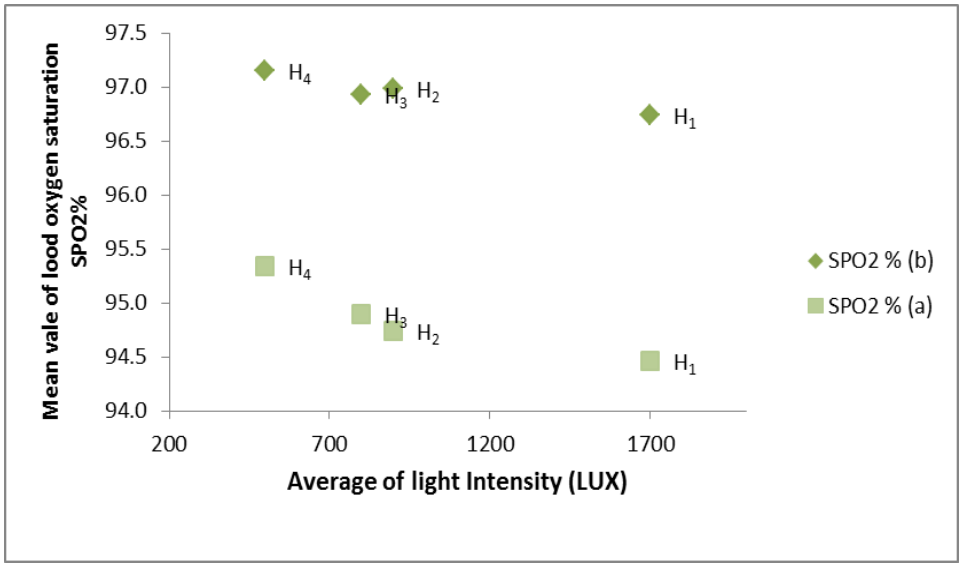

Fig. (4.6): Mean values of blood oxygen saturation (SPO_2 %) of nurses as a function of light intensity in night shift before (b) and after (a) exposure to light intensity.

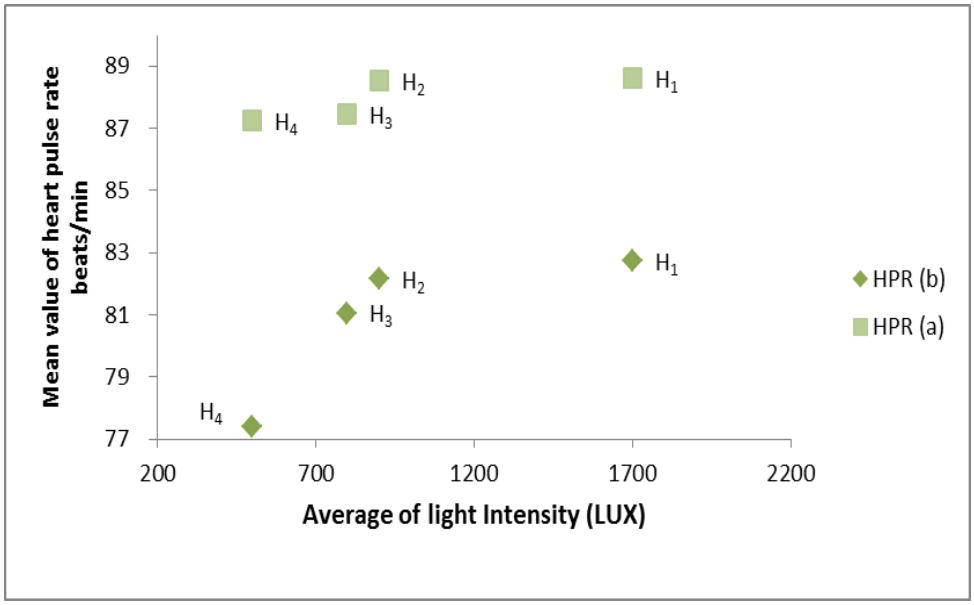

Fig. (4.7): Mean values of heart pulse rate (HPR) of nurses as a function of light intensity in night shift before (b) and after (a) exposure to light intensity.

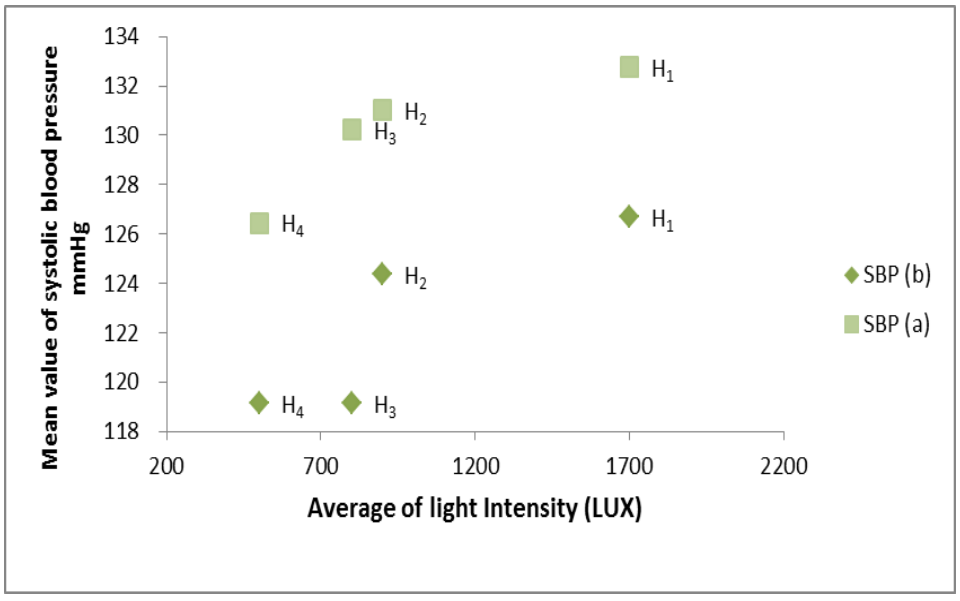

Fig. (4.8): Mean values of systaltic blood pressure (SBP) of nurses according to intensity of light in night shift before (b) and after (a) exposure to light intensity.

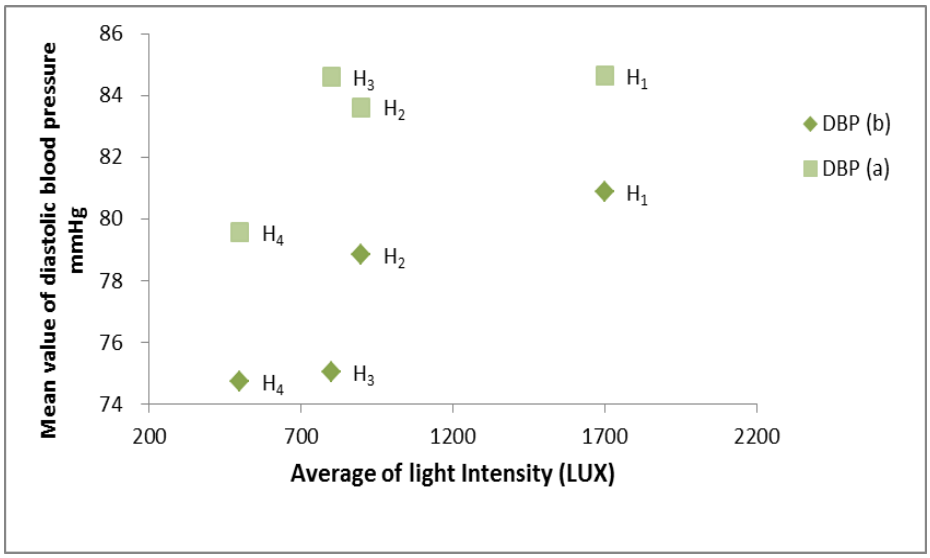

Fig. (4.9): Mean values of diastolic blood pressure (DBP) of nurses as a function of light intensity in night shift before (b) and after (a) exposure to light intensity.

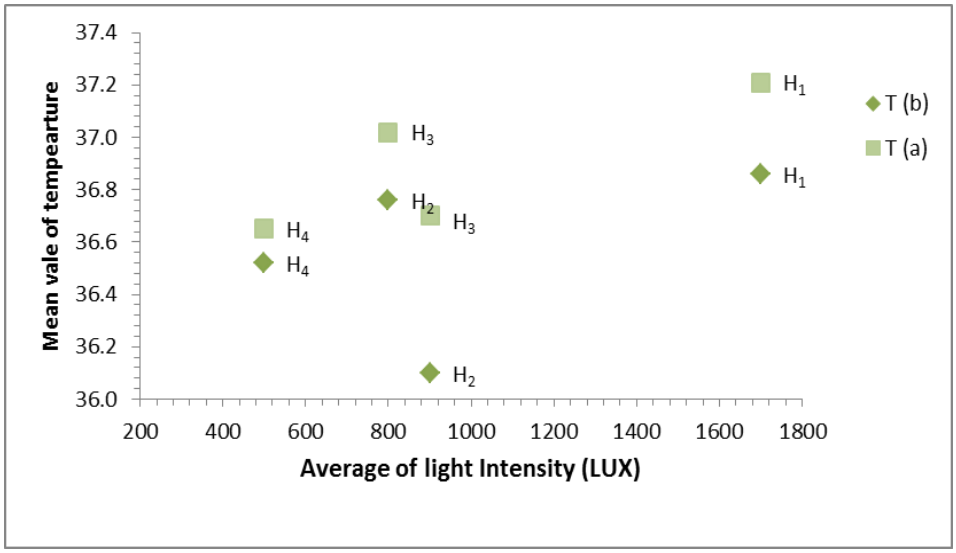

Fig. (4.10): Mean values of temperature (T) of nurses as a function of light intensity in night shift before (b) and after (a) exposure to light intensity.

4.4 Personal Health Effects Dependence

In this section there are some personal health effects such as age (Sec 4.4.1), duration of employments (Sec 4.4.2) are discussed.

4.4.1 Age Effect

The dependence of the mean value of blood oxygen saturation, pulse rate, blood pressure (systolic and diastolic) on the age of the nurses in the studied hospitals before(b) and after (a) exposure to light intensity are represented in (Figs 4.11 – 4.15).

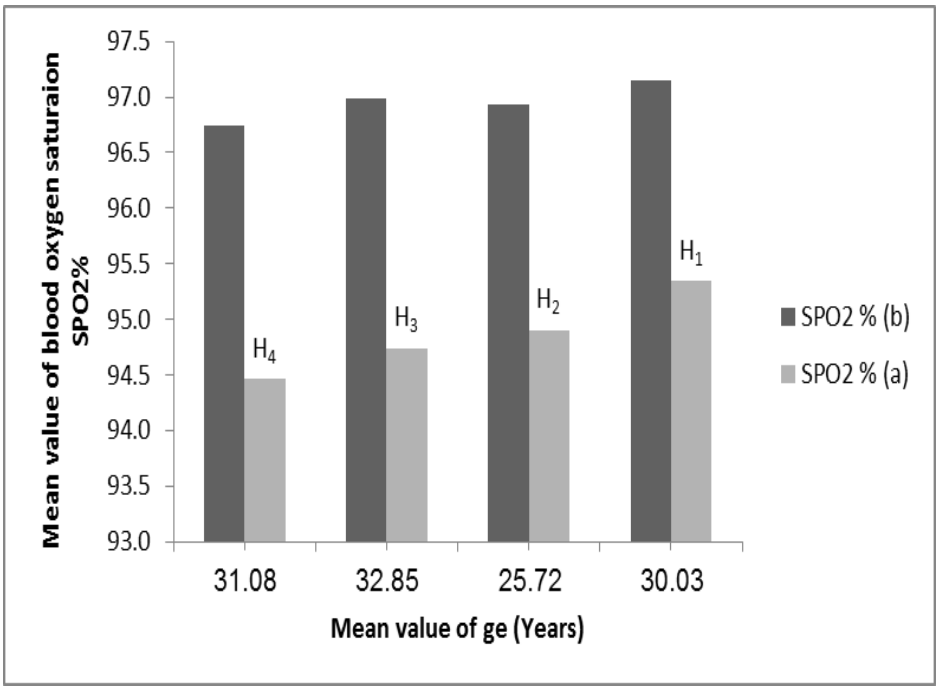

Fig. 4.11: Mean value of blood oxygen saturation (SPO_2%) of nurses as a function of mean value of age in each hospital before (b) and after (a) exposure to light intensity.

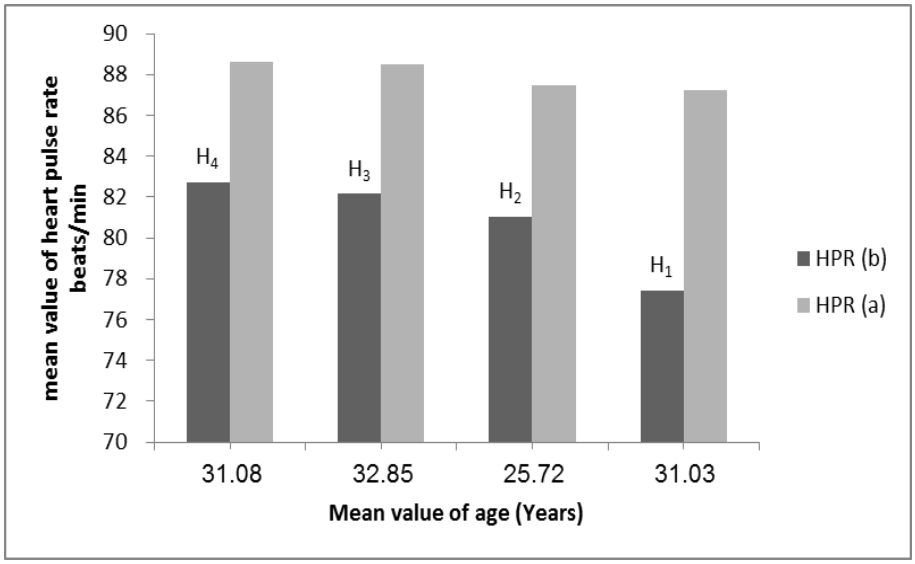

Fig. 4.12: Mean value of heart pulse rate (HPR) of nurses as a function of mean value of age in each hospital before (b) and after (a) exposure to light intensity

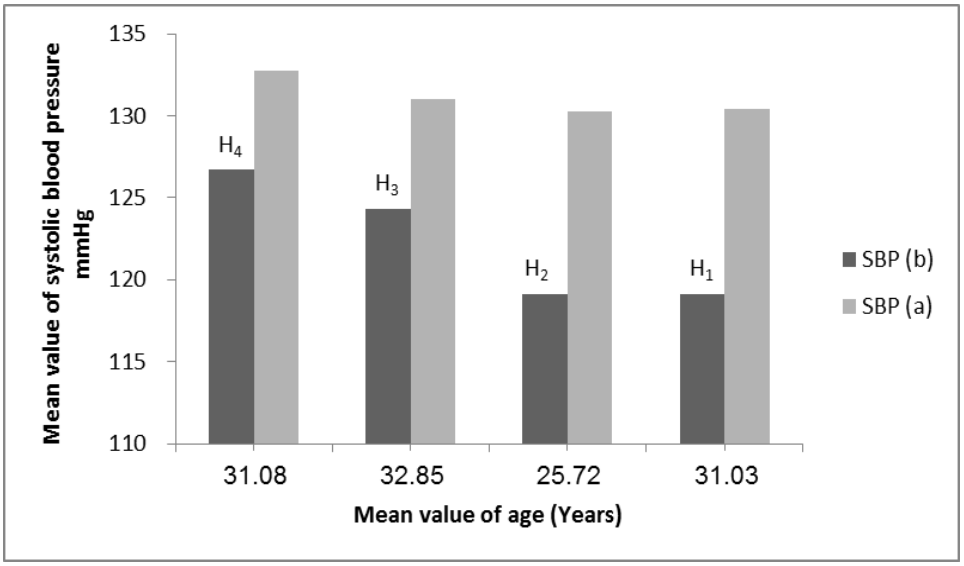

Figure 4.13: Mean value of systolic blood pressure (SBP) of nurses as a function of mean value of age in each hospital before (b) and after (a) exposure to light intensity.

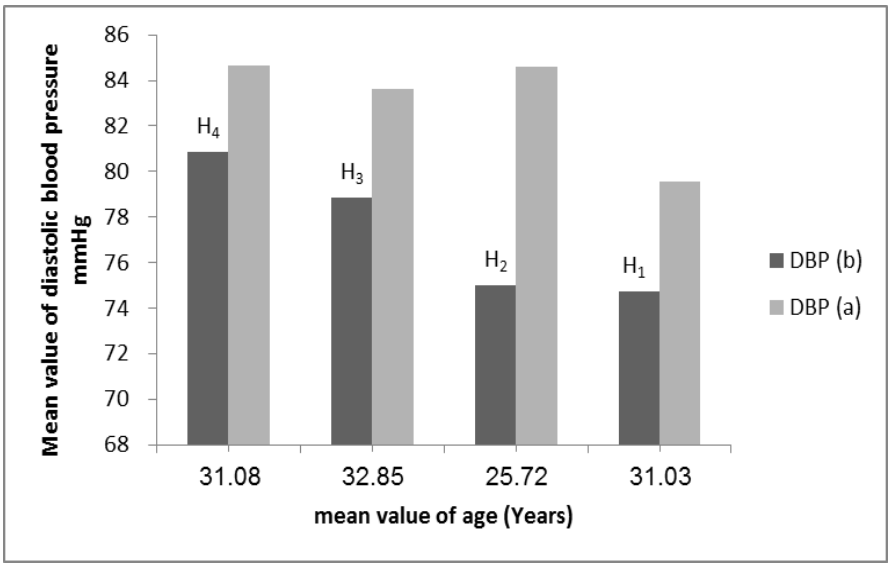

Figure 4.14: Mean value of diastolic blood pressure (DBP) of nurses as a function of mean value of age in each hospital before (b) and after (a) exposure to light intensity.

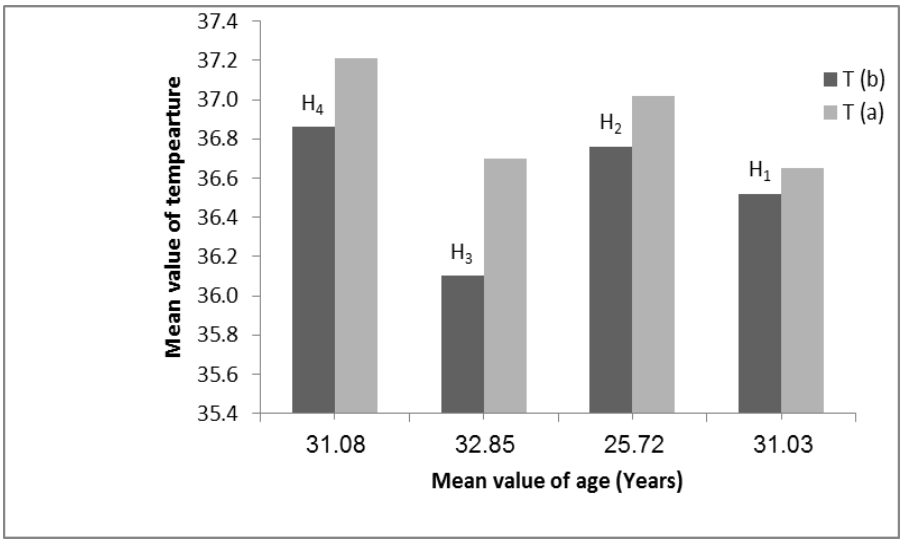

Figure 4.15: Mean value of temperature of nurses as a function of Mean value of age in each hospital before (b) and after (a) exposure to light intensity.

It can be observed that there is significant correlation between mean value of blood oxygen saturation, pulse rate, blood pressure (systolic and diastolic) and the age of the selected nurses in the studied hospital .

4.4.2 Duration of Employment Health Effects Dependence

The dependence of the mean value of blood oxygen saturation, pulse rate, and blood pressure (systolic and diastolic) on the duration of employment of the selected nurses in the studied hospital before (b) and after (a) exposure to light intensity are represented in (Figs 4.16 – 4.20).

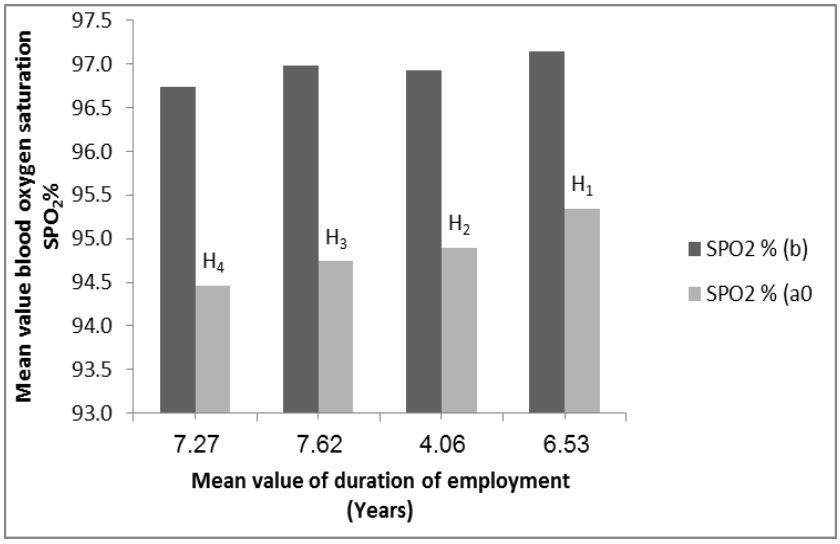

Fig. 4.16: Mean value of blood oxygen saturation (SPO_2%) of nurses as a function of Mean value of duration of employment in each hospital before (b) and after (a) exposure to light intensity.

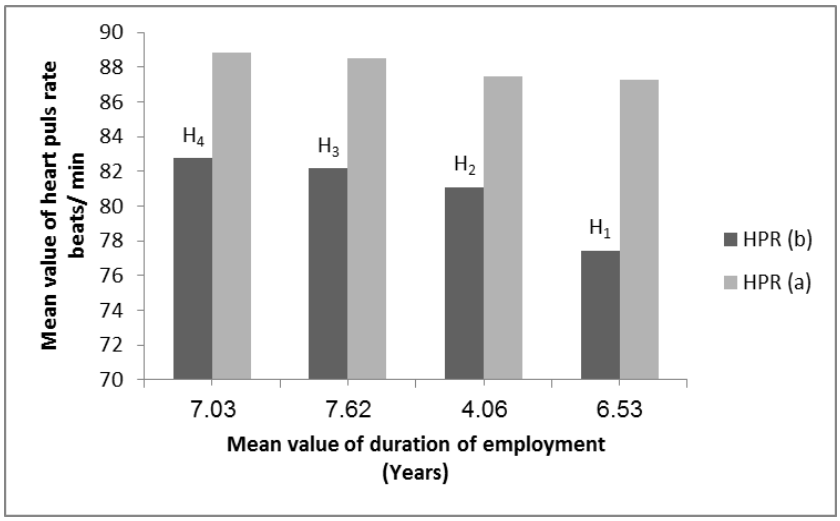

Fig. 4.17: Mean value of heart pulse rate (HPR) of nurses as a function of Mean value of duration of employment in each hospital before (b) and after (a) exposure to light intensity.

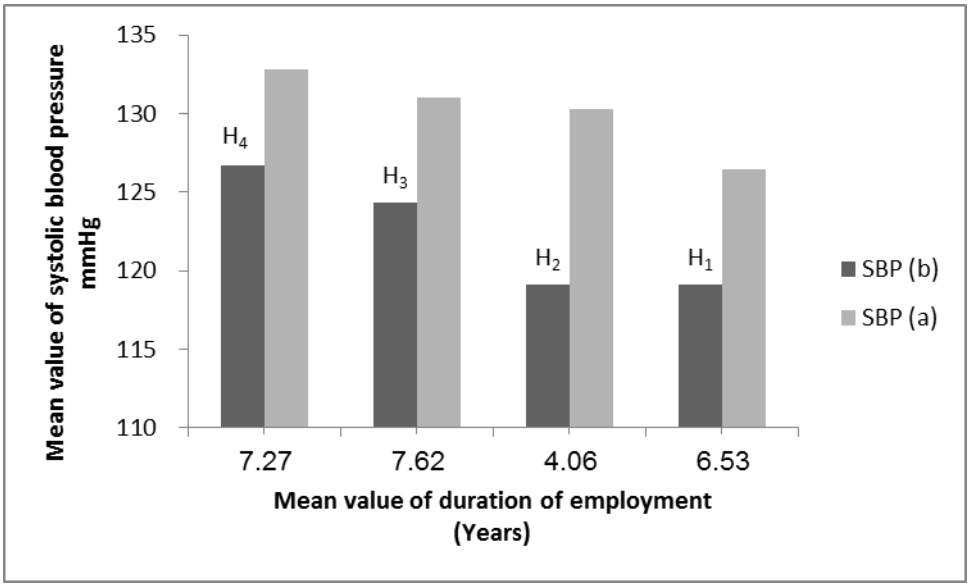

Fig. 4.18: Mean value of systolic blood pressure (SBP) of nurses as a function of Mean value of duration of employment in each hospital before (b) and after (a) exposure to light intensity.

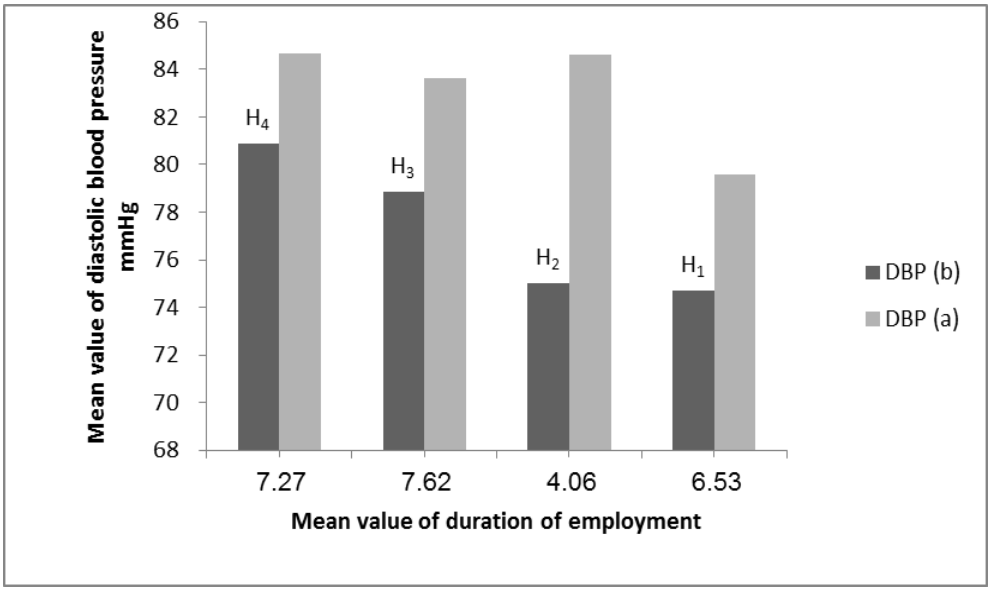

Fig. 4.19: Mean value of diastolic blood pressure (DBP) of nurses as a function of Mean value of duration of employment in each hospital before (b) and after (a) exposure to light intensity.

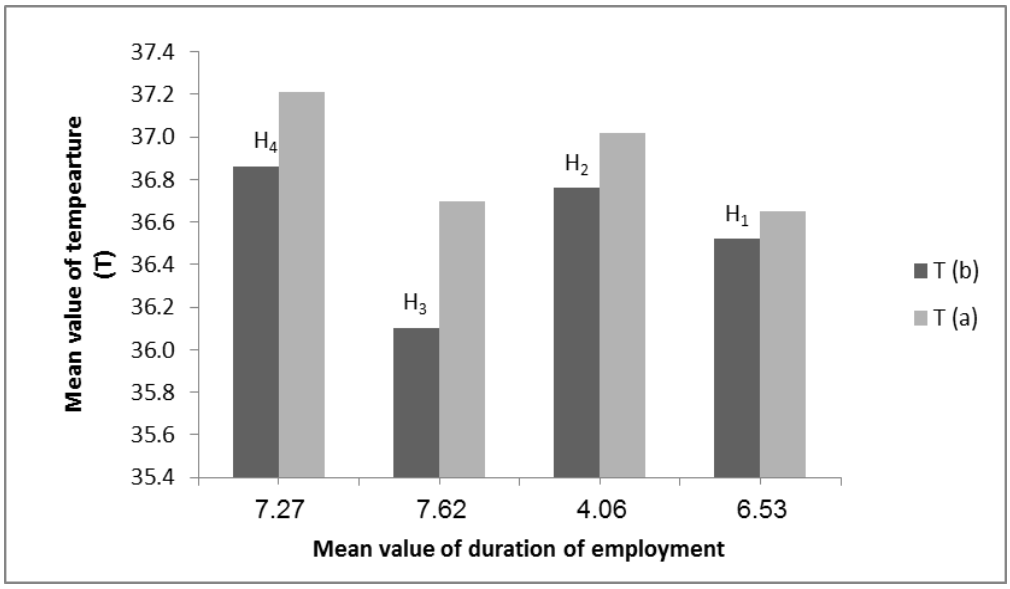

Fig. 4.20: Mean value of temperature of nurses as a function of Mean value of duration of employment in each hospital before (b) and after (a) exposure to light intensity.

It can be observed that there is significant correlation between mean value of blood oxygen saturation, pulse rate, and blood pressure (systolic and diastolic) and the duration of employment of the selected nurses in the studied hospital

Chapter Five

Discussion and Recommendation

5.1 Discussion

Light exposure study was carried out on four different hospitals in Nablus city. Light intensity in all studied hospitals ranged from 220 Lux to 1000 Lux at day shift and from 500 Lux to 1700 Lux at night shift.

The highest light intensity level (Table 4.1) was observed at Rafidia Governmental Hospital with (1000 Lux at day shift and 1700 Lux at night shift).The lowest at Union Hospital with (220 Lux at day shift and 500 Lux at night shift).

Effects of the light intensity on all parameters in night shift were more than in day shift, such as in Rafidia Governmental Hospital the change before and after exposure to light intensity in SPO_2% is 2.95% at day shift and 3.00% at night shift, and the change in tympanic temperature is 0.43 ^{0}C at day shift and 0.50 ^{0}C at night shift.

The results of measurements of blood pressure (systolic and diastolic blood pressure) show that there are an increase in values with an increase of light intensity in day and night shifts as shown in Figs. 4.4, 4.5, 4.9, and 4.10. That was the case in all hospitals, for all nurses and employment periods. The increment in blood pressure was less for young nurses than for older nurses (Figs.4.14 and 4.15). The newly employed nurses were more

affected by light intensity than their mates of higher employment periods,(Figs.4.19 and 4.20).

The strength of the results are good as can be understood from the Pearson correlation coefficient and Probability values between light intensity and blood pressure before and after exposure to light are 0.989, 0.985 at day shift, and 0.901, 0.915 at night shift. 0.011 and 0.015 at day shift ,and 0.015, 0.019 at night shift respectively (Tables 4.34 and 4.35). However the results of this study are in agreement with other studies which support that exposure to light intensity leads to increase blood pressure Pandi et *al*., 2006.

The behavior of heart pulse rate as a dependent variable showed a continuous increase with the increase of light intensity (Fig. 4.3) at day shift, and (Fig. 4.8) at night shift. This is in good agreement with the study conducted by Peng et *al*., 2001

There is a decrease in blood oxygen saturation with the increase of light intensity. That was the case in all hospitals, for all nurses and employment periods. It was clear that the increment in blood oxygen saturation is more for older nurses than for younger nurses and also those newly employed nurses were less affected by light intensity than their mates of higher employment periods. This is in complete agreement with the study conducted by Peng et *al*., 2001

The measurements for temperature showed that there is an increase in temperature with an increase of light intensity. That was the case in all hospitals, for all nurses and employment periods. The increment in

temperature is more for older nurses than for younger nurses. Those newly employed nurses are less affected by light intensity than their mates of higher employment periods. This agrees with the study conducted by Z. Zamanian 2010.

The statistical results of the dependent variables (H.P.R, SPO_2%, and T) showed that Pearson correlation coefficient between light intensity, (the dependent variable) is approximately equal to one, and the Probability is < 0.05. This indicates that there is a strong correlation (before and after exposure to light intensity) between light intensity and the dependent variables (Tables 4.34 and 4.35)

It is apparently noted that all factors (blood oxygen saturation, heart pulse rate, and blood pressure (systolic and diastolic), tympanic temperature) have increased during the night shift since the intensity of light is more than that during day shift.

This study showed that the effects of light intensity on human health depends on the light intensity itself. For example, the accepted illumination was in Union hospital (220 lux at day shift and 500 lux at night shift), while the bad effect on health performance for all nurses was less in Rafidia Governmental hospital (1000 lux at day shift and 1700 lux at night shift).

The net change in dependent variables before and after exposure to light intensity (Tables 4.28- 4.33) showed that the shift in blood oxygen saturation was 1.64% for LI 220 Lux and 2.95% for LI 1000 Lux, while the shift in heart pulse rate was 5.16 beats /min for LI 220 Lux and 9.16

beats/min for LI 1000 Lux. In the case of blood pressure, it was observed that the difference in SBP for LI 220 Lux and 1000 Lux were 6.02 mmHg and 11.62 mmHg, respectively. On the other hand, the difference in DBP for LI 220 Lux and 1000 Lux were 5.96 mmHg and 7.92 mmHg, respectively. Finally, the difference for T were 0.1 ^{o}C for LI 220 Lux and 0.43 ^{o}C for LI 1000 Lux.

The results of this study agree with the result of the other studies that say that SBP and DBP increase as light intensity increasing during night shift workers (Pandi et *al* 2006). It was found that nurses with seven hours exposure to 1700 Lux had higher blood pressure than the nurses who exposed to 500 Lux.**(9)**

It is observed that the net change in blood oxygen saturation was 3.32% for male and 4.17% for female, while the net change in pulse rate for males and females was 11.54 beats/min and 11.59 beats/min respectively. The shift in SBP was 11.35 mmHg for male and 12.33 mmHg for female. In case of DBP, the net change is 10.38 mmHg for male and 11.75 mmHg for female (Tables 4.29 - 4.30). The results indicate that the females are more affected by light than males. Our results show contradiction to the results of Monteleone P., 1997.

As a conclusion, when human expose to light intensity the body absorbs light according to Beer's law. The body produce a hormone of melatonin, this hormone affects on blood oxygen saturation, blood pressure (diastolic and systolic), heart pulse rate, and tympanic temperature.

5.2 Recommendation

The following are some recommendations which can be carried on to reduce the effect of light intensity on nurses' health:

1- Periodic tests for the workers should be done in order to determine the health effects of light intensity early

2- Control the light intensity in the corridors, nurse room and reception space to be in the range according to the world health organization (WHO) which indicates that is the recommended range (500 – 700) lux as average light intensity in all hospitals.

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Bi

Consent Form

نموذج موافقة على الاشتراك في الدراسة

أنا الطالبة نورهان فريد يوسف الشيخ محمد

جامعة النجاح الوطنية – كلية الدراسات العليا –قسم الفيزياء

أقوم بدراسة وذلك استكمالا لمتطلبات درجة الماجستير بعنوان

" **تأثير شدة الضوء على صحة الممرضين في فترات عملهم بالليل والنهار**"

اود الاشارة هنا بان اشتراككم في الدراسة لن يتطلب منكم ذكر الاسم او ذكر أي معلومات حساسة ويحق لكم عدم الاشتراك او التوقف عن الاشتراك في هذه الدراسة في أي وقت تشاؤون.

أي معلومات سنأخذها منكم ستكون لغرض البحث العلمي فقط.

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

2013

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الملخص

ألقت هذه الدراسة الضوء على تأثير شدة الاضاءة على عدد من العوامل الصحية مثل تركيز الأكسجين في الدم ونبض القلب و ضغط الدم (الانقباضي والانبساطي) ودرجة حرارة الجسم الداخلية. تم اختيار 207 ممرضين (104 أنثى و 103 ذكر) كعينة عشوائية من أجل تحقيق الهدف المنشود.

لقد تم أخذ هذه العينة من الممرضين من أربعة مستشفيات (حكومية وخصوصية) في مدينة نابلس حيث بلغت شدة الاضاءة (220– 1000) لوكس في فترة العمل الصباحي و(500–1700) لوكس في فترة العمل الليلي.

وقد تم اخذ عدد من القياسات ذات العلاقة بتركيز الاكسجين في الدم ونبض القلب وضغط الدم (الانبساطي والانقباضي) ودرجة حرارة الجسم الداخلي قبل التعرض لشدة الاضاءة وبعد 7 ساعات من التعرض لشدة الاضاءة. وقد وجد أن هناك علاقة قوية بين شدة الاضاءة وكل من تركيز الدم ونبض القلب وضغط الدم (الانقباضي والانبساطي) ودرجة حرارة الجسم الداخلي. حيث كان معامل ارتباط بيرسون بين المتغيرات وشدة الاضاءة تقريبا 1 والاحتمالية < 0.05

اظهرت هذه الدراسة ان تأثير شدة الاضاءة على الجوانب الصحية تعتمد على شدة الاضاءة بحد ذاتها، فقد تغيرت قيم تركيز الدم ونبض القلب وضغط الدم (الانقباضي والانبساطي) ودرجة حرارة الجسم الداخلي بشكل اكبر عند الممرضين الذين تعرضوا لشدة اضاءة 1700 لوكس من الممرضين الذين تعرضوا ل 220 لوكس.

حيث ان في فترة العمل الصباحي كان معامل ارتباط بيرسون بين شدة الاضاءة وتركيز الاكسجين بالدم (0.980)، والاحتمالية (0.020). بينما كان معامل ارتباط بيرسون لنبض القلب (0.966)، والاحتمالية (0.034). وبالنسبة لضغط الدم (الانقباضي والانبساطي) وجد أن معامل ارتباط بيرسون كان (0.985) والاحتمالية (0.015) ، بالإضافة كان معامل ارتباط بيرسون لضغط الدم الانبساطي (0.989) والاحتمالية (0.011)، وبالنسبة لدرجة الحرارة كان معامل ارتباط بيرسون (0.990) ولاحتمالية (0.010).

وهذا يعني ان هناك تأثير في فترة العمل الصباحي والمسائي ولكن التأثير في الفترة المسائية كان أعلى وذلك بسب ان شدة الاضاءة كانت اكبر.