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ТЕМА: « HYGIENIC EVALUATION OF AN INSOLATION MODE, NATURAL AND ARTIFICIAL LIGHTING OF LIVING, EDUCATIONAL, AND MEDICAL PREMISES (part 1,2)»

Methodical recommendations to the lesson
for students in the specialty 31.05.01 "General Medicine"

г. Волгоград, 2020 г.

The motivational description of the theme.

Light, electromagnetic radiation from 400 to 760 nm (nanometer) capable of producing a visual sensation, is one of the most essential components of the environment. It has a specific effect on eyesight and a person's ability to perceive light. Light gives more than 80% of information from the environment. It has a favorable effect on the human body, stimulates the person's vital activity, promotes metabolic processes, work capacity and productivity, improves general well-being and mood.

Light makes the environment healthier, i.e. "Where the sun does not shine, the doctor often comes". Inadequate, irrational lighting has a negative effect on the functioning of the visual analyzer. It increases its fatigability and that of the central nervous system. Bad lighting at a work place usually results in decreased work capacity and productivity of people and causes occupational traumatism.

The doctor has to be able to estimate the risk of inadequate lighting for the health of the patients as well as to give recommendations on the arrangement of lighting in a doctor´s office, operating room and in some other buildings (e.g. patient care institutions, educational establishments, houses, etc.).

The objective: to teach how to prognosticate visual malfunctions and decreased working capacity due to improper lighting; to learn the principles of arranging and monitoring natural and artificial lighting.

Students' classroom activities

1. Estimation of indoor natural lighting.
2. Estimation of indoor artificial lighting.
3. Stability of distinct vision**.**
4. Case problem (type 1, type 2).
5. Presenting and discussing individual students' reports.

Students' independent activities

1. Light & lighting. Hygienic importance of lighting.
2. Hygienic evaluation of an insolation mode in living, educational and patient care settings.
3. Hygienic evaluation of indoor natural lighting.
4. Hygienic evaluation of indoor artificial lighting.
5. Physiological methods of evaluating lighting sufficiency.

Plan of students' independent activities

1. Case problems. The solutions of the case problems should be reported in writing.
2. Examination and estimation of natural lighting/daylight in a classroom using the following indicators: light factor (LF), angle of incidence, aperture angle, daylight factor (see appendix).
3. Calculation and evaluation of the artificial lighting level in a classroom
4. Determination of the stability of distinct vision.

5. Drawing a conclusion about the conditions for the work of the visual analyzer in the classroom.
56. Presenting and discussing individual students' reports.

Reference information

Term descriptions

NATURAL LIGHTING is referred to as direct or indirect (reflected) light which penetrates through window openings and/or doors in the outer enclosing structures.
INSOLATION is referred to as penetration of direct solar rays through window and door openings.
COMBINED LIGHTING is a combination of natural and artificial lighting.
COEFFICIENT OF NATURAL LIGHTING is the ratio of natural lighting at a certain point within a building/room produced by direct or indirect light to the simultaneous value of external horizontal lighting produced by the light coming from a completely cloudless sky (it is expressed in %).
LOCAL LIGHTING is the lighting supplementary to general lighting produced by lamps whose light flux is directed immediately towards workplaces.
GENERAL LIGHTING is the lighting produced by the lamps regularly spaced in the upper part of the room or directed towards the equipment.
LIGHT CLIMATE - a total of all the natural lighting conditions in a certain area over the period of 10 years.
LIGHT FACTOR is the ratio of the glass area of windows to the area of the floor.
MIXED ILLUMINATION is the lighting when insufficient daylight is complemented with artificial lighting.
ANGLE OF INCIDENCE is the angle at which a light ray strikes a horizontal area in a room (e.g. desk, etc.); it is formed by two lines, a horizontal and a vertical one. The former is drawn from a certain point (the surface of the desk) to the lower edge of the window; the latter is drawn from a certain point to the upper edge of the window.
APERTURE ANGLE is the angle which determines the area of the sky which immediately illuminates the working surface. It is formed by two lines, upper and lower. The former is drawn from a certain point to the upper edge of the window, the latter is drawn to the highest point of the opposite building or tree.
STABILITY OF DISTINCT VISION is the ability of the eye to discern small pieces over a period of time.

Appendix

ESTIMATION OF NATURAL LIGHTING

Geometrical method

Determination of light factor

1. Measure the glass area of the windows in the room (window frames shouldn't be considered).
2. Calculate the glass area.
3. Determine the total area of the room.
4. Divide the glass area of the windows by the area of the room.

Standard light factor is as follows: in patient care institutions it is 1:4-1:6; in residential buildings - 1:8-1:10.
This method of estimating the light factor is rather simple, however, it has some limitations. It does not consider orientation of buildings, dimming caused by opposite buildings and/or trees, etc.
The estimation of natural lightning considering the shape and location of windows, height of the opposite buildings, the distance from a workplace to the window involves determining entrance angles, i.e. the aperture angle and the angle of incidence.

Determination of the angle of incidence (pic 1)

1. Measure the horizontal distance from the workplace to the window (L).
2. Measure the height of the window.
3. Determine the ratio H:L = tg.
4. Determine the angle of incidence of light as the tangent of an angle (use "Table of natural values of tangents")

The standard angle of incidence of the workplace should be no less than 27º.
The more the angle of incidence, the better lit the room is. The further the desk is from the window, the less the angle of incidence is. Hence, it is more poorly lit.

Determination of the aperture angle (pic 2)
1.Determine the auxiliary angle. The student should sit at a desk and visualize drawing a line from the surface of the desk to the highest point of the opposite building which can be seen through the window. Another student should mark a certain point on the glass of the window through which this line passes. The student should measure the vertical distance from the plane of the window-sill to the given point. Then, the ratio of this distance to the horizontal distance from the workplace to the window which was determined when we calculated the angle of incidence should be calculated. It is the tangent of the auxiliary angle. The value of the auxiliary angle should be determined according to the "Table of natural values of tangents".
2. Determine the aperture angle. It can be calculated using the following equation:
Aperture angle = Angle of incidence – Auxiliary angle
The standard aperture angle should be no less than 5º.
The larger the sky area seen from the window, the more the aperture angle is. Hence, the room is better lit.

LIGHT MEASUREMENT (most rigorous method)
This method is used for quantitative assessment of natural lighting by calculating daylight factor. The latter is the integrated index of daylight level considering all the factors influencing its distribution in the room.
Determination of coefficient of natural lighting. Measure natural lighting (NL internal) in a certain point, namely, at a distance of 1 m from the wall which is most distant from the window and door openings and at the intersection of vertical

centre section of the room and the working plane. It is measured in lux, by a luxmeter.

1. Light intensity in an arbitrary point in the same horizontal plane lit with diffused sky light (NL external) should be measured too.
2. The daylight factor can be calculated using the following equation:

Coefficient of natural lighting = (NL (internal) / NL (external)) x 100%

The standard coefficient of natural lighting **(**minimal values) considering the parameters of visual work done in this room:
operating-room, laboratory, classroom – 1.5%;
doctor´s consulting room, treatment room – 1%;
residential premises, ward – 0. 5%.

Evaluation of artificial lighting

Evaluation of sufficient lighting is based on the level of luminous flux density, i.e. lighting intensity.

Methods of lighting measurement

1. Photoelectric (using an objective lux meter);
2. Computation method based on lamp specific output (Watt method).

Approximate method of computing artificial lighting (Watt method):

1. Calculate the number of lamps in the room.
2. Calculate the total lamp wattage in watt (by multiplying the number of lamps by lamp wattage).
3. Calculate specific output in watt/m² (by dividing the total wattage by the total area of the room).
4. Calculate artificial lighting in lux (by multiplying specific output by the L coefficient which shows the number of luxes generated by the specific output equal to 1 watt/m²). The standard coefficient L for 100 watt incandescent bulbs is 2.0; the standard coefficient L for 100 watt and more powerful incandescent bulbs is 2.5; the standard coefficient L for luminescent lamps is 10.

Intention of a building, type of work performed in the room, small-sized objects necessary for work, a distance from the person’s eyes to them, contrast between the object and its background, the speed required for the distinction of the objects, adaptation conditions for the eyes, presence of dangerous objects which can cause occupational traumatism should be considered when estimating the quality of artificial lighting in the room.

Table 1

Standard artificial lighting

Type of room	Minimum permissible lighting, lx
1. Educational establishments:	
Classroom, consulting-room	300

Classroom for drawing	500
Gymnasium	200
Rest room	150
Hall, lavatory	75
2. Pre-school educational establishments:	
Nursery, playing-room, dining-room, a room for musical studies	200
Bedroom	75
3. Residential buildings:	
Room, kitchen	100
Bathroom, hall	50
4. Patient care institutions:	
Operating room, resuscitation room (general lighting)	500
Operative (surgical) site (combined lighting)	2000-30 000
Doctor´s consulting room	300
Ward	100
Dental office (general lighting)	500
Patient’s oral cavity (combined lighting)	3000-4000
Pharmacies	
Workplace of a dispenser in a public service room	300
Personnel, clean and packaging rooms	400
Wash room	150

All the standards above are relevant to lighting produced by luminescent lamps. If incandescent bulbs are used, artificial lighting standards are twice as low. As visual sensitivity to light produced by luminescent lamps is lower than that produced by incandescent bulbs, lighting intensity produced by luminescent lamps should be 2-3 times higher in similar lighting conditions.

Physiological methods of evaluating lighting

In addition to light measurement methods lighting sufficiency can be evaluated by studying visual acuity, stability of distinct vision and other functions of the visual analyzer (speed of visual distinction, time required for dark adaptation, etc.) These methods involve determining visual fatigue during visual performance which largely depends on lighting conditions.

Determining the stability of distinct vision

A subject fixes his eyes on a small, hardly discernible part – a broken Landolt ring depicted in a table for testing visual acuity (at a distance of 2.5-3 meters) for 3 minutes. The part can be either clearly discernible or fuzzy and obscure. The subject should signal the moments (e.g. by raising a finger) when he can’t see the part quite clearly and when it becomes sharp again (by lowering a finger). Another student should record the time when the finger is raised or lowered.

When the test is over, a total of all the **time spans** when the part was sharply seen should be calculated. The stability of distinct vision is determined as the ratio of the total time of distinct vision to the total test time (180 sec.) in % .
It is necessary to test the stability of distinct vision before work, 1, 2 or hours after it started to determine the degree of visual fatigue and evaluate lighting conditions. This can also help observe the way the function depresses over time. When the lighting is sufficient the results of final measurements will approximate to their initial values in similar lighting conditions. When the lighting is insufficient there will be a sharp decline in the stability of distinct vision: in three hours of visual performance when the lighting is 200-300lx only by 10-15% (in relation to the initial value taken as equal to 100%), when it is 100lx – by 26%, when it is 50 lx – by 63%).

Table 2

Description of light sources

Type of a lamp	Description
Incandescent lamp	Easy to handle. Predominance of the yellow and red parts in the spectrum. Low efficiency coefficient. Inefficient use of electric power (5% – light, (95 % - heat). They run hot, heat up the air. Considerable brightness of filaments. Short life cycle.
Quartz-halogen bulb (sophisticated incandescent lamps)	High luminary efficiency. Stable bright light during the whole life cycle. Long life cycle. Small size. Possibility to regulate light flux High level of security
Luminescent lamps	Emission spectrum similar to that of daylight High luminary efficiency. Low heating temperature. Cycle economy. Extended life cycle. A start-control device (noise). Light flux pulsation. Utilization problems (presence of mercury).
Energy saving bulbs (compact fluorescent lamps)	Emission spectrum similar to that of daylight High luminary efficiency Low heating temperature Cycle economy. Extended life cycle. Small-sized lamps. New generation start-control devices (noiseless). Devoid of optical effects of flickering.

	Utilization problems (presence of mercury).

Table 3

Orientation of buildings according to the part of the world in different climatic regions

Climatic region	Orientation according to the part of the world	Colour gamma
I (cold)	South, Southeast, southwest	Warm colors (orange, pink, beige, yellow)
II (moderate)	South, Southeast, southwest	
III(warm)	South, Southeast	Cold colors (blue, violet)
IV (hot)	South, Southeast	
Operating - rooms	South	Grey-green, green-blue

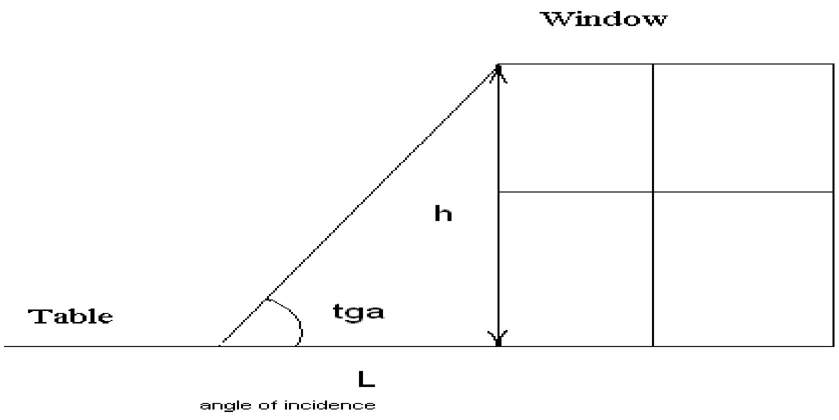
Table 4

Natural values of tangents.

Lo	tgL	Lo	tgL	Lo	tgL
1	0.017	16	0.287	31	0.601
2	0.035	17	0.306	32	0.625
3	0.052	18	0.325	33	0.649
4	0.070	19	0.344	34	0.675
5	0.087	20	0.364	35	0.700
6	0.105	21	0.384	36	0.727
7	0.123	22	0.404	37	0.754
8	0.141	23	0.424	38	0.781
9	0.158	24	0.445	39	0.810
10	0.176	25	0.466	40	0.839

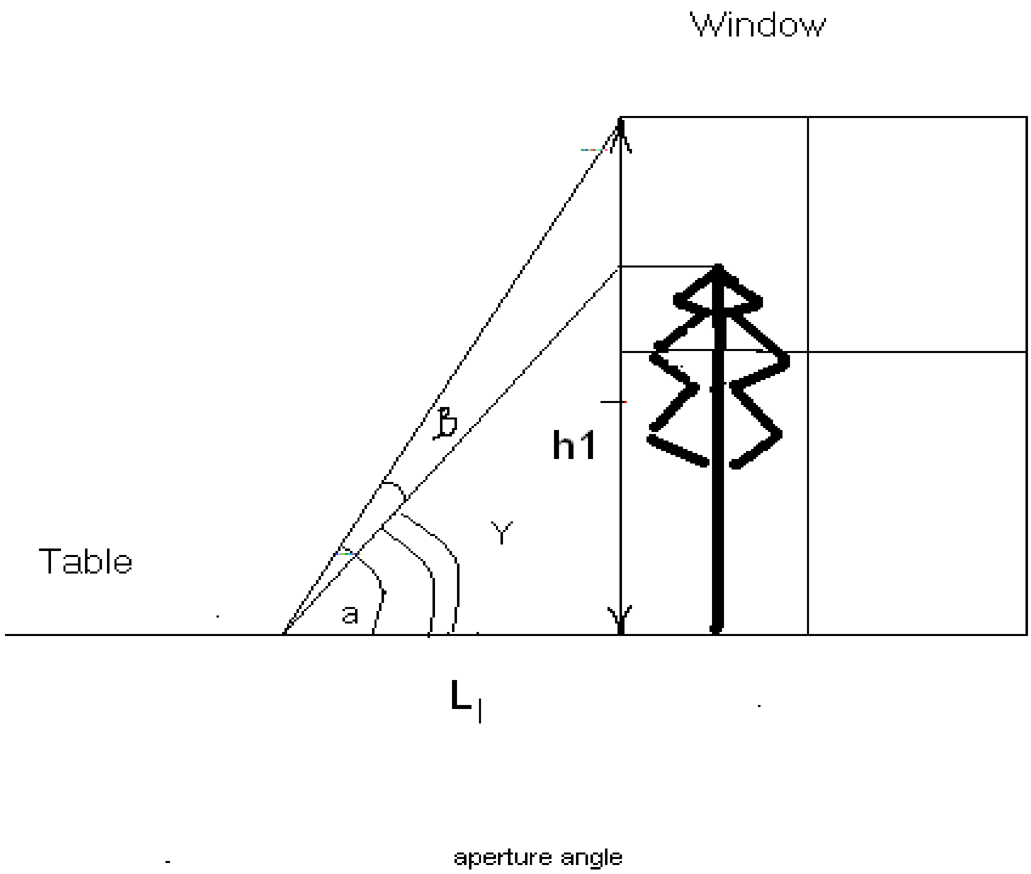
11	0.194	26	0.488	41	0.869
12	0.213	27	0.510	42	0.900
13	0.231	23	0.532	43	0.933
14	0.249	29	0.554	44	0.966
15	0.268	30	0.577	45	1.000

Angle of incidence



Pic.1

Aperture angle.



Pic.2