MESOPIC VISUAL ACUITY REQUIREMENTS FOR DRIVING LICENCES IN THE EUROPEAN UNION - RESEARCH REPORT

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SUMMARY

In this study different methods for determining the mesopic visual acuity in candidates for driving licences group 2 are presented (Royal Decree, 1998, European norms). Results of normal subjects are compared. Depending on the method used, visual acuity obtained under mesopic conditions, with an illuminance of 1 lux, showed a mean ranging from 0.5 to 0.65, which is clearly above the legal norm of 0.2.
A comparative study of the three published official norms demonstrates that the stringent norms of 1966 do not match those of 1988 and 1998, resulting in a wider margin of acceptability, to the advantage of the candidate.

SAMENVATTING

In deze studie worden verschillende methoden voorgesteld voor het bepalen van de mesopische gezichtsscherpte bij kandidaten voor rijbewijs groep 2 (Koninklijk Besluit, 1998, Europese reglementering). Hierbij worden de resultaten van normale proefpersonen vergeleken. Afhankelijk van de gebruikte methode wordt, in mesopische omstandigheden bij een verlichtingssterkte van 1 lux, een gemiddelde gezichtsscherpte van 5/10 tot 6.5/10 bekomen, welke duidelijk boven de wettelijke norm van 2/10 is gelegen.

Een vergelijkende studie tussen de drie gepubliceerde officiële reglementeringen toont aan dat de strenge normen van 1966 niet overeenkomen met deze van 1988 en 1998, waarbij een ruime marge werd gecreëerd in het voordeel van de kandidaat.

RÉSUMÉ

Dans cette étude, différentes méthodes sont présentées pour la détermination de l'acuité visuelle mésopique chez les candidats au permis de conduire du groupe 2 (Arrêté Royal, 1998, normes Européennes). Les résultats obtenus chez des sujets normaux sont comparés.
En fonction de la méthode employée, les résultats notés dans les conditions mésopiques, avec un éclairement lumineux de 1 lux, donnent une acuité visuelle moyenne de 5/10 à 6.5/10, clairement dépassant la norme légale de 2/10.
L'étude comparative des trois normes légales publiées nous montre que les normes sévères, appliquées en 1966, contrastent avec celles de 1988 et de 1998, résultant en une plus grande marge en faveur du candidat.

KEY-WORDS

Photopic / mesopic / scotopic vision, illuminance, luminance, dark adaptation, Goldmann-Weekers adaptometer

MOTS-CLÉS

Vision photopique / mésopique / scotopique, éclairement lumineux, luminance lumineuse, adaptation à l'obscurité, adaptomètre de Goldmann-Weekers.

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received: 05.09.01
accepted: 04.10.01

INTRODUCTION

In 1966, the examination of the light sense of car drivers became mandatory for the first time in Belgium and the requirements and methods of examination were outlined in a Ministerial Decree. Since then, these norms have twice been changed quite markedly (Table 1).
Light sensitivity sense (1966) and vision in twilight (1988/1998), the terms used in the protocol form (eye examination - candidate for driver licence group 2) are defined as ''mesopic visual acuity''(*) by the ''Physiological optics'' Commission of the Belgian Institute for Normalization (BIN) (5).
In the context of the transition from photopic vision to scotopic vision, the term *''mesopic vision''* or *''mesopic visual acuity''* seems more appropriate than both ''light sensitivity sense'' and ''vision in twilight''.
The luminance levels for photopic, mesopic and scotopic vision are defined as follows:
- for photopic vision (cone function):
  $>$ 10 cd/m^2
- for scotopic vision (rod function):
  $<$ 0.01 cd/m^2 and
- for mesopic vision (cone-rod function):
  $\pm$ 0.2 cd/m^2 (1) (5).

In this context it is useful to mention that a dull white surface, reflecting all entering light in a diffuse way, has a luminance of about 0.2 cd/m^2 at an illuminance of 1 lux. This demonstrates that 1 lux is an illumination rate situated in the transition zone between pure photopic and pure scotopic vision.

We also know that a candle positioned at a distance of 1 meter from a homogeneous white flat surface generates an illuminance of 1 lux. Moreover, this illuminance is inversely proportional to the square of the distance to the source of light (inverse square law) (1).
Results of measurements (measuring instrument Tektronix) at different distances, when using a candle or an incandescent lamp of 15 W respectively, confirm this inverse square law very accurately (fig. 1).

Ten years after an initial adaptation of the legislation in 1988 (RD 06/05/1988), the Belgian legislation concerning the driving licence was again adapted, this time to the European

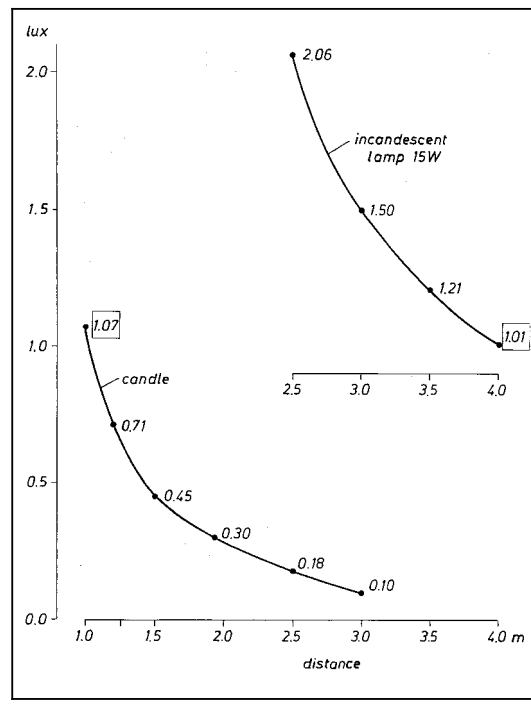

Fig 1. Results of the illuminance of a candle and an incandescent lamp at different distances (m).

Table 1: *Belgian requirements for mesopic visual acuity of the candidates for driving licence group 2, stated by Ministerial Decree (MD) or Royal Decree (RD) published in the Belgian Statute Book (BSB).*

		ILLUMINATION optotype	BINOCULAR VISION at 5 meter
MD 07/07/1966	BSB 21/07/1966	0.1 lux	0.2
RD 06/05/1988	BSB 28/09/1988	0.3 lux	0.1
RD 23/03/1998	BSB 30/04/1998	1.0 lux	0.2

(*) DEFINITION of the mesopic visual acuity: measurement of the visual acuity for one or more low and specified illumination levels of an optotype table.

directives (RD 23/4/1998). Article 5 of these directives on ″Vision in twilight'' states:
''In order to be capable to drive a car, the candidate must have a visual acuity of at least 0.2, if necessary with correction, after 5 minutes of dark adaptation. The visual acuity is measured binocularly by means of an optotype scale, illuminated with 1 lux and at a distance of 5 meter of the candidate.'' In case of doubt a more specific examination with an adaptometer is needed. The maximal allowed deviation is 1 log unit.

However the practical set-up of a simple test to measure vision in twilight according to the European directive is not straightforward. Few ophthalmologists possess a lux meter, let alone one sensitive enough to measure 1 lux.
Hence, experiments performed in the consultation room of the ophthalmologist are no more than approximative and are mostly based on estimates of the correct conditions. Such improvisation usually results in an overestimation of the mesopic acuity.
In this study, we discuss the possibilities in the consultation rooms of the ophthalmologist to obtain an illuminance rate of 1 lux on a scale of optotypes, required for a valid examination of the mesopic visual acuity.

MATERIALS

Fifteen normal volunteers (aged between 26 and 60 years) underwent visual acuity measurement at 5 meters, after 5 minutes adaptation in mesopic conditions at an illuminance of 1 lux, using three different methods (projector equiped with neutral density (ND) filters; a stearin candle or an electric lamp).

METHODS

Direct methods

1. A simple stearin candle, put in a dark room at a distance of 1 meter of an optotype, provides an illuminance of approximately 1 lux on the optotype (fig. 1, 2). Although such a setting seems less appropriate in a modern ophthalmological unit, this test yields reliable results (3).
2. A standard incandescent lamp of 15 Watt (e.g. Osram®, Luxor®), in a dark room at a distance of 4 meter of an optotype, provides an illuminance of approximately 1 lux (fig. 1, 2).
3. A darkened examination room, with homogeneous spot illumination, equiped with a dimming system up to 1 lux, as measured on the optotype.

Indirect methods

1. Modifications of a standard optotype projector
   a. A gelatin-gray filter, e.g. Agfa-Gevaert or Kodak Wratten, neutral density (ND) of 2.0 log units and transmission (T) = 1 %, placed in a free space of the projector or just in front of the projector outlet. Although projectors and accessory projector lamps may vary, we assure that they radiate almost the same intensity of light. Indeed, any projector and lamp, as lower part of the unit, has to conform to the standard requirements concerning light intensity, in order to achieve the same measurements of vision.
   b. A pair of polarized filters (5), one rotating filter and one fixed filter, in front of the projector outlet (e.g. a neutral linear polarizer, ref. HN 32, available on the market).
   c. An electronic system for dimming the halogen lamp of the projector to 1 lux. A light feedback system with triac and light sensor or a commercial manual dimmer.

2. A gray filter (ND 2.0 log units) in front of each eye on the trial frame.

3. Diving goggles with a mounted gray filter (ND 2.0 log units).

All those indirect methods allow for easy modification of the amount of transmitted light, such that the illuminance equals 1 lux, as measured at the optotype.

Important remarks regarding methods

The mesopic visual acuity is measured in a dark room.

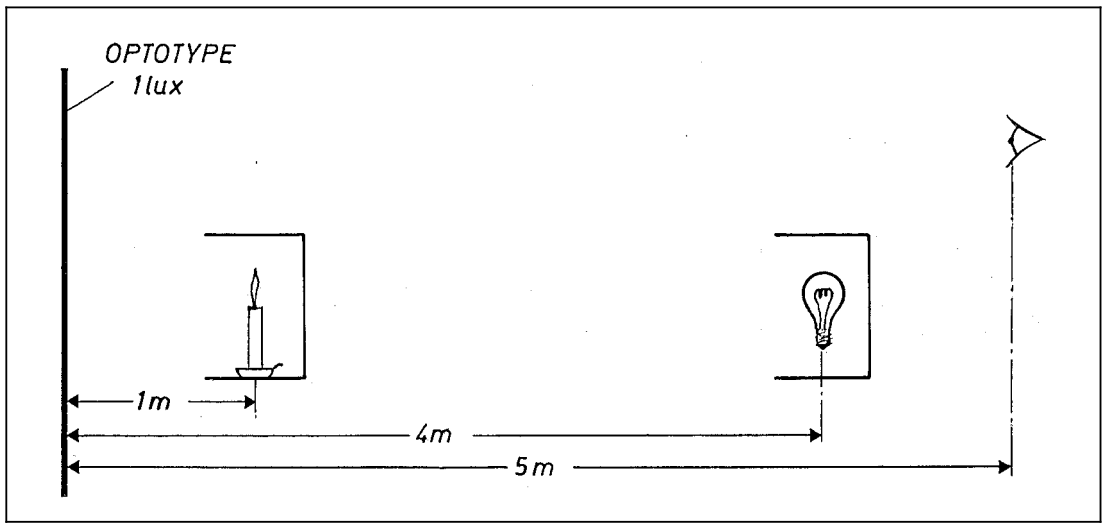

Fig 2. Set-up with stearin candle (1 m) and incandescent lamp of 15 W (4 m) to obtain the necessary illuminance of 1 lux.

- The obtained lux value can show a small error when using an incandescent lamp, as a consequence of small technical differences between lamps of different manufacturers, voltage fluctuations of the network and aging of the lamp. In this regard it is recommended not to use the lamp until the filament breaks, but to replace it after a few hundred hours.
- When using direct methods (1 and 2) the stearin candle or the electric lamp are placed in a closed box with the inside painted in dull black and one side open towards the optotype, such that the entire lamp is visible as seen from the optotype (fig. 2).
- Gelatin-gray filters are no more produced since several years by the rising of the digital photography. For that reason the methods using neutral density filters are difficult to realize.

EVOLUTION OF THE EXAMINATION

Adaptation in mesopic conditions

According to the legal decrees of 1966 and modifications of 1988 and 1998, the candidate has to be dark adapted for 5 minutes (scotopic conditions). However, an adaptation to an illuminance of 1 lux corresponds to mesopic conditions (5).

In our opinion, the candidate has to adapt not to scotopic but rather to mesopic conditions (1) (3) (5). Hence, subjects in this study were adapted as follows:
During 5 minutes, the candidate looks at a homogenous white flat surface, illuminated with 1 lux, e.g. the white back of an optotype chart or in case of a projector the metal screen at a distance of 5 meter.

Determination of the mesopic visual acuity

After adaptation the actual optotypes are shown (the optotype chart is turned around) or projected.

ADAPTOMETRY

If the mesopic visual acuity is less than 0.2 or in case of doubt more specific examination with an adaptometer is needed (R.D. 1998). This is performed in our clinic with the Goldmann-Weekers adaptometer, using the Chevalier-Jayle principle (integral level determination), to measure the absolute sensitivity level of the whole visual field during the process of dark adaptation (Ganzfeld stimulation) (2).

A dark adaptation time takes 20 minutes of examination. The first phase of examination con-

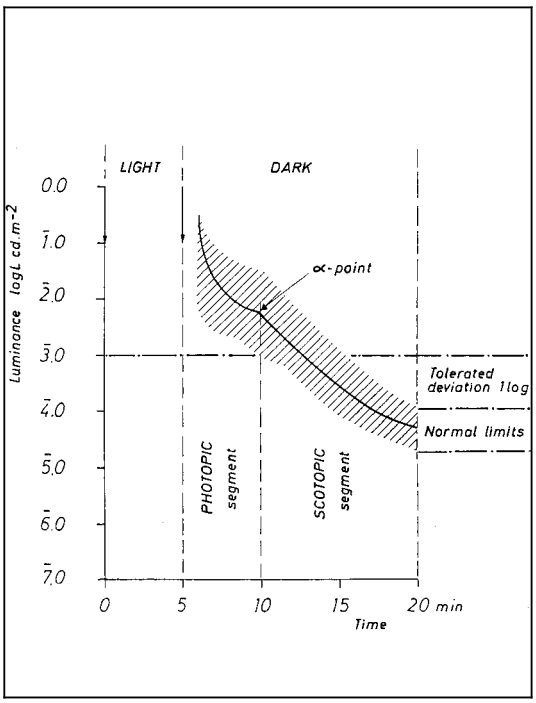

Fig 3. Mean dark adaptation curve within the normal range in photopic, scotopic and mesopic vision (breaking point between the photopic en scotopic segment: (α-point or Kohlrauch point) with the Goldmann-Weekers adaptometer. A sensitivity level increase of more than 3 log units is considered unacceptable.

sists of a light adaptation during 5 minutes of the whole visual field binocularly at an homogeneous luminance of about 670 cd/m^2.
Immediately after that the second phase, the real dark adaptation in total obscurity during 15 minutes, follows. The results are shown in a diagram with the logarithm of the luminance in ordinate (log L cd/m^2) plotted against time (4,5).
In general, a normal subject would reach a maximal sensitivity level after 15 minutes of examination. The normal range of the luminance (log scale) is situated between about 4,0 and 5,0 cd/m^2.

Since the maximum divergence allowed is 1 log unit (RD 1998, European norms), it can be concluded that a dark adaptation curve after 15 minutes of examination with a sensitivity level of more than 3 log units (1 log unit above the normal limit) is unacceptable (fig. 3).

RESULTS AND CONCLUSIONS

With an optotype (object characters), illuminated with 1 lux (actual norms, RD 1998) the mean mesopic visual acuity (m) obtained in normal subjects with a candle or a lamp of 15

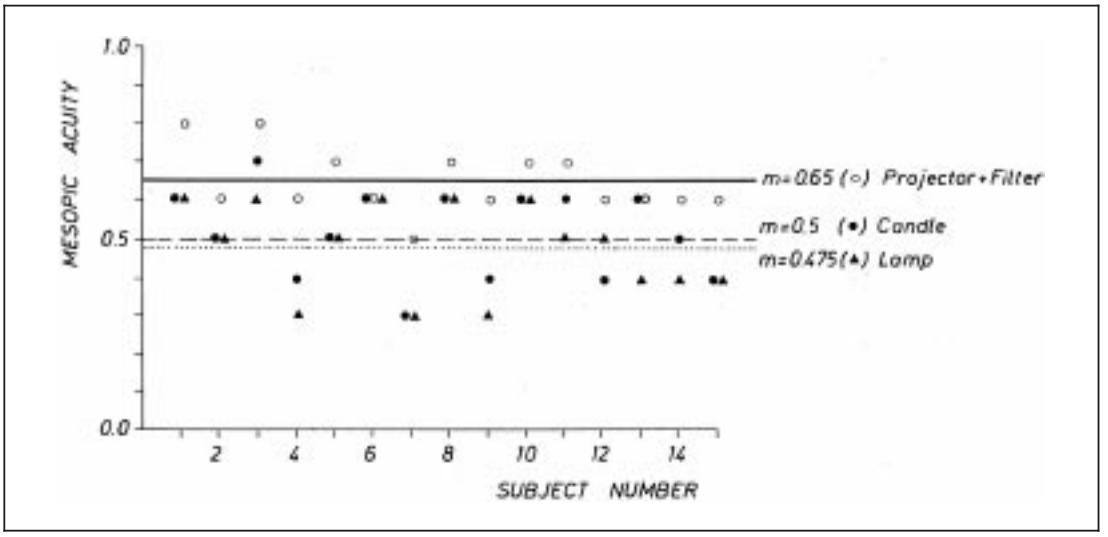

Fig 4. Results of 15 normal subjects (vision ⩾ 1.0, age 26 to 60 years), with three different sources of light, at the same illumination of 1 lux as recommended by the actual European regulation (RD 1998). Mean mesopic visual acuity (m): 0.5 (range 0.4-0.7) with candle (●); 0.475 (range 0.3-0.6) with incandescent lamp of 15 W (▲) and 0.65 (range 0.5-0.8) with projector + filter 2 log (o).

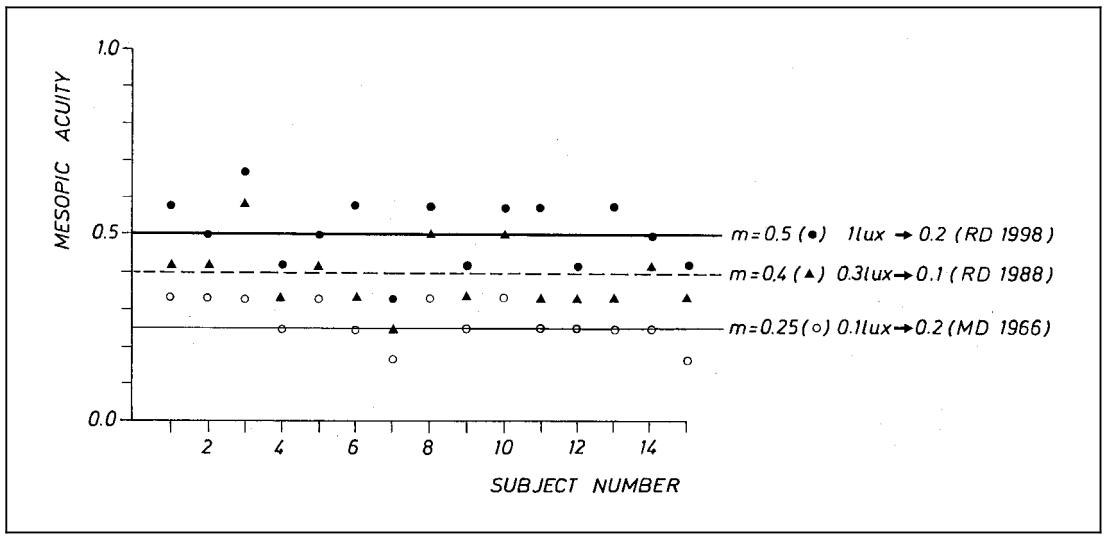

Fig 5. Results in three different illumination levels with a candle as light source. Mean mesopic visual acuity (m): 0.25 (range 0.167-0.33) at 0.1 lux (o), MD 1966; 0.4 (range 0.25-0.58) at 0.3 lux (▲), RD 1988 and 0.5 (range 0.33-0.67) at 1 lux (●), RD 1998.

W is almost identical: 0.5 (range 0.4-0.7) versus 0.475 (range 0.3-0.6). On the other hand, with a projector equiped with a filter of 2 log (object E), the mean mesopic visual acuity is 0.65 (range 0.5-0.8). This difference might be due to the reflection of the metal plate (shining silver), which enhances contrast. There is thus a difference in measured mesopic acuity of 0.15 (15 %) with the projector as compared to old-fashioned optotypes (fig. 4).

Fig. 5 gives us the strict norms of the RD in 1966, namely a vision of 0.2 at 0.1 lux. Our normal subjects reached a mean score of 0.25 (range 0.167-0.33). Subjects 7 and 15 had a mesopic visual acuity below this limit.
With an illumination of 0.3 lux, the mean vision was 0.4 (range 0.25-0.58), thus well above the 0.1 of the 1988 decree.
With an illumination of 1 lux, the mean vision was 0.5 (range 0.33-0.67), again well above the minimum requirements of 0.2 of the 1998 decree. Hence, the more relaxed requirements, stipulated in the RD 1988 and RD 1998, allow for a wide margin of 0.3 to the advantage of the candidate (fig. 5).

The fact that all subjects in this study had mesopic visual acuity levels well above the minimum requirement of the RD 1988 and RD 1998, questions the usefulness of such measures where almost every candidate succeeds. Indeed, further research may prove the latter. Consequently, ophthalmologists may well be tempted not to perform mesopic visual acuity tests any longer.

Although further studies on larger series of patients are necessary, our results also suggest that the number of subjects who require further examination with adaptometry will be very limited. In our opinion, it is probable that in a very small number of subjects, who obtain the necessary minimum of the new European requirements, a medical certificate of ability is unjustly delivered. This study further suggests that both a candle or an incandescent lamp of 15 W, as well as a projector with polarized filter or an electronic system, can be used successfully to measure mesopic visual acuity in a reliable way. However, the use of a metal projection plate is not recommended when using a projector.

Obviously, it is advisable to perform a screening test in the specific environment of each ophthalmic consultation room, with a few normal subjects.

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