Journal of Ophthalmology & Visual Sciences

Open Access

Austin Publishing Group

Research Article

Evaluation of Visual Disability with Digital Systems

Sangiuolo R[1]*, Brusini P[2], Carlini L[3], Cruciani F[4], Sangiuolo G[1], Sangiuolo M[5], Stefanucci M[6] and Sulfaro M[4]

[1]Fondazione italiana oftalmologia digitale e robotizzata - F.I.O.D.E.R (Italian Foundation of Digital and Robotic Ophthalmology, Italy

[2]Department of Ophthalmology, "Città di Udine" Health Clinic, Udine, Italy

[3]University of Perugia Head of Terni: SC of Forensic Medicine at Hospital Santa Maria, Italy

[4]Italian National Centre of Services and Research for the Prevention of Blindness and Rehabilitation of the Visually Impaired, WHOCC, IAPB Italy Onlus, FPG IRCCS, Roma, Italy

[5]NHS Latina Pontino Center University of Roma "La Sapienza", Department of Ophthalmology, Terracina, Italy

[6]Department of Economics, Business, Mathematics and Statistics, University of Trieste, Italy

***Corresponding author:** Raffaele Sangiuolo, Fondazione italiana oftalmologia digitale e robotizzata - F.I.O.D.E.R (Italian Foundation of Digital and Robotic Ophthalmology), Via Pordenone, 41-33100 Udine, Italy

Received: July 19, 2021; **Accepted:** August 11, 2021; **Published:** August 18, 2021

Abstract

Background: Vision loss is a major health issue and people with visual impairments are at higher risk for visually related complaints, as poor postural control, accompanying fear of moving and higher risk for falls compared to people with normal vision. Consequently, it is important to develop and improve treatment and prevention programs aimed at reducing these problems. In this endeavour, high quality screening instruments are a prerequisite for successful research and clinical practice.

Scope: The aim of this study is to verify the validity level of a new system for assessing the degree of visual disability that provides a numerical score, resulting from a combined assessment of both the Visual Field (VF) and Visual Acuity (VA) loss, obtained using a digital technology visor.

Methods: To verify if the assessments of the visual impairment coefficient carried out through the two different systems produce homogeneous results, a comparison between results obtained on a group of sixty-five subjects who were visually impaired or had fragile vision was performed.

Results: A great level of inhomogeneities in the evaluation of visual disability coefficient, obtained through the digital system, which provides for the combined evaluation of the visual field and visual acuity, and the conventional one, which involves the separate evaluation of the two parameters, was found.

Conclusions: These results confirm therefore that the discrepancies found in the assessment of the disability level obtained through two different systems is not due to the different tools used, but to the different evaluation systems. The evaluation system carried out using the new digital visor, which provides for the combined evaluation of the VF and VA, constitutes a method to ensure a more homogeneous and reliable visual disability assessment compared to those carried out with traditional systems.

Keywords: Visual residual coefficient; Visual disability; Digital visor

Introduction

Vision screenings are largely subjective and can be inaccurate since the results may vary based on who conducts the screening, the type of training provided, and the protocol employed. Differences in visual acuity values can also be attributed to varying guidelines or tools and, even if within the European Union there are widespread vision screening recommendations, current practices are non-standardized and vary by state and locality.

Furthermore, the equipment present in the various medico-legal centers does not have to follow a uniform standard by law; finally, there remains the great bias for which to be evaluated, and possibly compensated, is only the subjective, central visual and/or campimetric performance: this aspect leaves a good margin for action to the simulators and, more importantly, excludes from a correct evaluation people with cognitive deficits, whose damage would probably be framed more in invalidity than in blindness, unless otherwise demonstrated damage to the visual apparatus, and inductively.

In Italy, those aspects become particularly relevant for legal purposes because are combined to some critical issues that the law number 138 (Classification and Quantification of Visual Handicap and Ophthalmic Investigations, stipulated the 3rd of April 2001 138/2001), which establish criteria for classification in mild, moderate, or severe visual disability or partial or total blindness, encounters in its application for the assessment of the level of visual impairment.

Law 138/01 leaves ample room for the judgement of the expert and the discretion of the Commissions, which do not have a guideline to comply with to define the level of visual impairment, and are often based on the combined assessment between an impromptu visit and the material. Produced by the appraisal: certifications, in large percentage drawn up for clinical and non-medico-legal purposes (i.e. upon presentation of a binding SSN and not as a cost-effective service requested on a white prescription), sometimes accompanied by instrumental tests, even these not always the most appropriate nor suitable for a correct evaluation.

Usually, only the separate evaluation of the two main visual parameters: Visual Acuity (VA) and Visual Field (VF) are taken into consideration) [1].

The World Health Organization classifications proposed over the years also refer to these two parameters; indeed, for the visual field it does not propose a method of quantification as the Italian legislation does.

Citation: Sangiuolo R, Brusini P, Carlini L, Cruciani F, Sangiuolo G, Sangiuolo M, et al. Evaluation of Visual Disability with Digital Systems. J Ophthalmol & Vis Sci. 2021; 6(3): 1053.

In order to quantify functional visual impairment from a clinical point of view, subjective tests must be used that involve the patient's full cooperation. The tests used are of a psychophysical nature, that is to say they evaluate the extent of an eminently psychic reaction to a physical stimulus [2-4]. It follows that there are numerous variables that can interfere in a more or less decisive way, which include the following:

- The subject examined (previous experiences with the material used, familiarity with the letters and in general the cognitive component) and the particular situation in which he finds himself being fully aware, being in the forensic field, of the advantages that could derive from certain of his answers
- The characteristics of the instrument used (the size of the optometric table, its luminance, the contrast between the object and the background, the shape of the object, its graphic characteristics, the grouping of letters to form words) [4];
- The distance at which the test is performed;
- The environment (lighting, distance);
- The examiner (emotional expectation of improvement or tendency to aggravate a condition, excessive margin of discretion for the interpretation of the results).

Conducting the two exams (VA and VF) in virtual reality conditions [1, 6,7] guarantees a series of advantages:

- Take the exam in an everyday environment [8].
- It allows you to better control the many interferences due to ambient lighting and luminance of the devices.
- It allows an automatic calculation, through the algorithm of the digital viewer software [9], of the visual impairment coefficient and consequently to enter the patient in the competent level of the disability scale.
- It can take into consideration the other parameters of the visual function and relate them to both the VA and VF.

The authors have already proposed in a previous study [10] new guidelines for those affected by visual impairment in order to ensure a good level of visual capacity assessment, homogeneously implemented over the entire national territory, which employs a well-codified procedure using the combined examination of binocular VF [7,11-13] and VA. In the same article it was shown an excellent correlation between the results obtained using the digital visor and traditional systems concerning the assessments of VA and VF, which constitute the visual factors underlying the determination of the visual impairment coefficient. The same study showed a great level of inhomogeneities in the evaluation of visual disability coefficient, obtained through the digital system, which provides for the combined evaluation of VF and VA, and the conventional one which involves the separate evaluation of the two parameters.

The purpose of this study, conducted on a group of subjects who were visually impaired or had fragile vision, is:

- To compare the results produced by the evaluations carried out through the traditional systems, currently adopted by the judging committees, and the Global Vision Evaluation System (GVES) proposed by the Authors. The comparison was carried out both for all the cases examined and for the different types of defects (central, peripheral and mixed) in order to evaluate the effectiveness of the two different systems also in relation to the type of defect.
- To compare the level of validity of the assessment expressed through two different systems with and without simultaneous evaluation of VA and VF. To support the validity of this type of comparative assessment, some images which reproduce the real quality of individual vision, were reported.

Material and Methods

Sixty-five subjects aged between 14 and 80 years were considered in this study. Of these, 34 were affected by a defect in the central visual field (within 30°), 10 in the peripheral field (outside 30°), and 21 had mixed defects.

All the clinical tests were performed at the Italian National Centre of Services and Research for the Prevention of Blindness and Rehabilitation of the Visually Impaired at Gemelli Hospital - "Polo Nazionale di Servizi e Ricerca per la Prevenzione della Riabilitazione Visiva degli Ipovedenti" (IAPB) in Rome. Patients were enrolled in the period between November 2018 and March 2019.

All patients underwent a full ophthalmic examination including binocular VA and binocular VF assessment performed both through traditional systems [7] and through the GVES digital technology visor. A Visual Disability Coefficient (VDC) was calculated for each patient, through the special algorithm contained in the software of the digital viewer, obtained integrating the values of the binocular VF and VA.

All subjects gave written informed consent before being included in the study. No protocol was submitted to an Ethics Committee prior to initiating the study, as it is an observational study that does not assign treatment to the participants. The investigations were carried out following the guidelines of the Declaration of Helsinki. All subjects received detailed information about the aims of the study. Participation was voluntary and subjects were free to withdraw consent at any time without consequences to their care.

It was decided in an arbitrary manner to create a rating scale with five levels to not deviate much from the one currently in use. The level of evaluation obtained for each patient through the digital system was compared with the five-level scale currently adopted.

We considered belonging to:

- Level 1 (total blind) those who have a mere perception of light without recognition of structured stimuli.
- Level 2 (partially blind) those who have a percentage of visual impairment between 99.9 percent and 98 percent.
- Level 3 (severely visually impaired) those who have a percentage of visual impairment between 97.9 percent and 94 percent.
- Level 4 (medium-severe visual impairment) those who have a percentage of visual impairment between 93.9 percent and 86 percent.

Table 1: Assessment of visual impairment calculated by visor and committee.

	Committee Assessment	Level 1	Level 2	Level 3	Level 4	Level 5	no inv
Visor Assessment	Level 1	0	0	0	0	0	0
	Level 2	0	10	2	0	1	0
	Level 3	2	6	2	2	0	1
	Level 4	0	3	4	2	2	4
	Level 5	0	2	2	0	1	7
	no inv	0	1	1	0	1	9

- Level 5 (mildly visually impaired) those who have a percentage of visual impairment between 85.9 percent and 72 percent.

To optimize the processing quality of the levels of this scale, it was reproduced on a digital image, through the successive application of quantitatively pre-defined aberrant filters for each level of the VA and VF. This procedure made it possible to reproduce, with an excellent approximation, the vision of the subject examined and optimize the choice of the evaluation scale levels.

Results

The comparative analysis of all the results regarding the level of assessment of the degree of visual impairment calculated through the GVES and that expressed with traditional systems is reported in Table 1.

Statistical analysis

We computed the confidence interval (α=0.10) for the proportion of coherent valuations between the two assessments: CI = [0.269, 0.478]. This means that every value greater than 0.478 would be rejected as a null hypothesis of the corresponding binomial test, so a true coherence of 50% or more is very unlikely. This is a strong evidence of the difference between the two evaluation systems.

Confidence intervals (α=0.10) for the proportion of coherent valuations, as well as under-assessments and over-assessments have been computed, following statistical methodology for multinomial data. The results for the whole sample are the following:

Coherent valuations: 36.9%, CI= [26.1, 48.5]

Under-assessments: 29.2%, CI = [18.5, 40.8]

Over-assessments: 33.8%, CI = [23.1, 45.4]

These quantities have been calculated also according to the defect type (central, peripheral and mixed).

The results for the group of central defects are:

Coherent: 35.2%, CI = [20.6, 50.4]

Under-assessments: 38.2%, CI = [23.5, 53.3]

Over-assessments: 26.5%, CI = [11.8, 41.5]

For peripheral defects are:

Coherent valuations: 40.0%, CI= [20.0, 64.9]

Under-assessments: 0.0%, CI = [0.0, 24.9]

Over-assessments: 60.0%, CI = [40.0, 84.9]

For mixed defects:

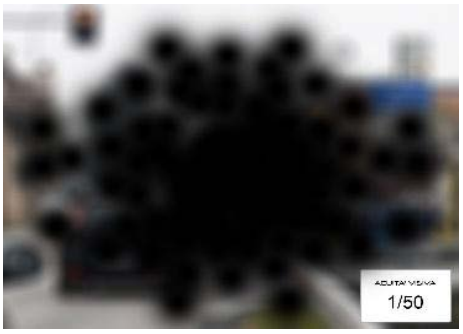

Figure 1: Subject with visual acuity equal to 1/50 and 16% residual VF (coefficient of visual impairment = 99.6%). With the adoption of the digital system, it must be entered in level 1 of the scale while the judging commission has entered it in level 3.

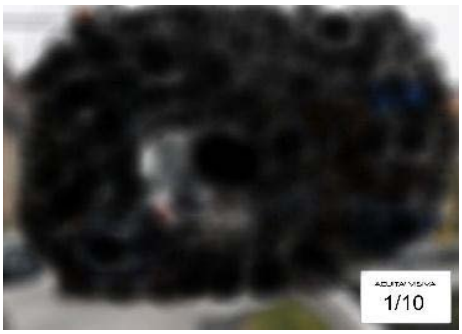

Figure 2: Subject with visual acuity equal to 1/10 and an 11% residual VF (coefficient of visual impairment = 98.9%). With the adoption of the digital system, it is entered in level 2 of the scale while the judging commission has entered it in level 4.

Coherent valuations: 38.1%, CI= [23.8, 60.1]

Under-assessments: 28.6%, CI = [14.3, 51.3]

Over-assessments: 33.3%, CI = [19.0, 56.1]

The differences among groups are not statistically significant.

We also conducted a test to verify the association between the concordance of valuation and the type of defect. The Chi-squared statistic was equal to 6.4963 with 4 degrees of freedom, corresponding to a p-value equal to 0.165 that means no association between variables.

We also study the association between coherence and age trough a generalized linear model with binomial response, and the relation is found to be not significant (p=0.32).

Figure 3: Subject with visual acuity equal to 1/10 and 50% residual VF (coefficient of visual impairment = 95%). With the adoption of the digital system, it must be entered in level 4 of the scale, while the judging commission has entered it in level 2.

Figure 4: Subject with visual acuity equal to 2/10 and 47% residual VF (coefficient of visual impairment = 90.6%). With the adoption of the digital system, it must be entered in level 4 of the scale while the judging commission has entered it in level 2.

Figure 5: Subject with visual acuity equal to 3/10 and a 96% residual VF (coefficient of visual impairment = 71.2%). With the adoption of the digital system, it must be entered in "non disability" level of the scale while the judging commission has entered it in level 2.

The great level of inhomogeneities found in the results obtained through the digital system and the conventional one is not due to the different tools used, as was explained in a previous article, which is why it is evident that it is due to the evaluation system adopted. This finding forced us to make a comparison regarding their validity. We analyzed for each subject the photographic reproduction of their vision obtained through the system above described.

The reproduction of the aberrations induced by the visual deficits previously assessed with the digital viewer, clearly showed the best evaluation quality of the visual impairment level expressed through the digital system. A simple visual analysis has made evident consistently a good congruity between the evaluation expressed with the use of the digital viewer and the images of the relative photographic reproductions and a low level of congruity between the images of the reproductions and the level of disability expressed by the commissions through the current procedures. Below are reported some examples that clearly highlight the different qualitative level expressed through the adoption of the two different evaluation systems. The following images are illustrated in a succession linked to the decreasing level of visual impairment:

The analysis of the comparison between the photographic reproductions demonstrates a good level of congruity between the image reproducing the eyesight and the level of disability expressed through the digital evaluation, contrary to what happens in the case of those expressed by the various commissions carried out following the current legislation.

For example this evidence appears clearly from the comparison between the evaluation expressed with the conventional system in the patient 5 (entered in level 2) and the patient 1 (entered in level 3).

Discussion

From the comparative analysis of the assessments relating to the visual disability degree carried out digitally in the five examples it is clear the importance of adopting a system that provides a combined assessment of visual acuity and binocular visual field.

A low level of congruity between the reproduction of the patient's vision and the judgment expressed by the various commissions appears evident in a considerable percentage of cases analyzed, while it appears extremely high in the case of digital evaluations.

From the analysis of the results, there is a significant lack of homogeneity between the results of the evaluations expressed by the various commissions and those expressed through digital evaluations. In particular, a good degree of homogeneity can be found in 35.4% of total cases only.

The causes of these discrepancies may lie in:

- Failure to simultaneously assess the deficits relating to visual acuity and those relating to the visual field.
- Different system used for evaluating low visual acuities.
- Different degree of influence of environmental factors (brightness, contrast, examination distance etc.).
- Unevenness of the examination systems used for the assessments adopted by the various commissions.
- Difficulty in expressing, objective and quantifiable results as they are obtained through subjective and unevenly processed data.

The lack of homogeneity in the judgments expressed by the various commissions depends also on the lack of homogeneity in the tools used to perform the evaluation.

Conclusions

Several reasons favour the use of a digital technology visor over traditional methods. Firstly, test results are numerically defined

and standardized with no interference from environmental factors (luminosity, test distance, instrument component wear, etc.). Secondly, the disability percentage, calculated from the residual visual coefficient, can be expressed immediately at the end of the examination, thus producing a fast and simplified evaluation procedure. Thirdly, it would be possible to institute a nationwide well-codified homogeneous assessment system based on a single standard testing instrument instead of the numerous non-standardized instruments currently in use.

In sum, the digital visor would provide standardized and reproducible examination results as it produces an automated numerical expression of the percentage of visual disability and this would promote greater uniformity of judgment in centers tasked with assessment.

Declaration

Author Contributions: Conceptualization and methodology, writing original draft preparation: R.S and P.B; Software: G.S; Validation, formal analysis and investigation: F.C and M.Su; Data curation: M.S; Critically reviewed the last draft of the paper G.G and M.L; Supervision M.B and L.C; Statistical analysis: M.St.

Acknowledgments: The Authors thanks Dr. Margherita Guidobaldi and Dr. Roberto Perilli for assisting in patient testing and data collection and Dr. Roberto Perilli for having made his experience available to us in the judging committees.

References

1. Sangiuolo R, Amore F, Bacci M, et al. Valutazione della percentuale di invalidità visiva attraverso un visore a tecnologia digitale. Riv It Med Leg Dir in campo sanitario. 2019: 939-937.
2. Lovie-Kitchin JE. Validity and reliability of visual acuity measurements. Ophthalmol Physiol Opt. 1988; 8: 363-370.
3. Arditi A, Cagenello R. On the Statistical Reliability of Letter-Chart Visual Acuity Measurements. Invest. Ophthalmol Vis Sci. 1993; 34: 120-129.
4. Moganeswari D, Thomas J, Srinivasan K, Jacob GP. Test Re-Test Reliability and Validity of Different Visual Acuity and Stereoacuity Charts Used in Preschool Children. J Clin Diagn Res. 2015; 9: NC01-NC05.
5. Chang HH, Liu JY, Huang CL, Cheng CY, Li C-Y. Assessment of the validity and reliability of the Simplified Visual Acuity Chart when administered to adults 65 years of age and older. Taiwan J Public Health. 2006; 25: 303-309.
6. Sangiuolo R, Brusini P, Cruciani F, et al. Global visual evaluation system: un visore digitale per una completa valutazione delle capacità visive. Oftalmol Soc. 2019; 2: 44-50.
7. Esterman B. Functional scoring of the binocular field. Ophthalmology. 1982; 89: 1226-1234.
8. Sangiuolo R, Brusini P, Sangiuolo M. Valutazioni funzionali con sistemi digitali. Relazione Ufficiale Soc. Oftalmologica Italiana. 2020. Capitolo 10.
9. Sangiuolo R, Bacci M, Brusini P, et al. Valutazione delle capacità visive attraverso un indice visivo globale. Riv It Med Legale.Editore Giuffrè Francis Lefebvre. 2020.
10. Sangiuolo R, Brusini P, Cruciani F, et al. A new system for assessing visual disability using a digital viewer. J. Clin. Med. 2020; 9: 1086.
11. Bentley SA, LeBlanc RP, Nicolela MT, Chauhan BC. Validity, Reliability, and Repeatability of the Useful Field of View Test in Persons with Normal Vision and Patients with Glaucoma. Invest. Ophthalmol Vis Sci. 2012; 53: 6763-6769.
12. Quang Nguyen D, Cheung CY, Aung T, Yin Wong T, Cheng C-Y. The Effect of Testing Reliability on Visual Field Sensitivity in Normal Eyes - The Singapore Chinese Eye Study. Ophthalmology. 2018; 125: 15-21.
13. Tan NYQ, et al. The effect of testing reliability on visual field sensitivity in normal eyes: The Singapore Chinese Eye Study. Ophthalmology. 2018; 125: 15-21.