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ORIGINAL ARTICLE

# Pupil diameter, working distance and illumination during habitual tasks. Implications for simultaneous vision contact lenses for presbyopia

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**KEYWORDS**
Multifocal contact lens;
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Working distance

**Abstract**
*Purpose:* To determine working distance, pupil diameter and illumination in real life conditions in a sample of presbyopic participants performing habitual tasks.
*Methods:* A total of 59 presbyopic subjects (aged between 45 and 63 years) with different occupational backgrounds participated in the study. Participants were first interviewed regarding their habitual tasks with the aid of an ad hoc questionnaire, following which in-office photopic and mesopic pupil diameter was determined. Pupil diameter was also evaluated while participants conducted each of the self-reported habitual tasks by taking a photograph, which was later submitted to image analysis. In addition, working distance was determined with a measuring tape and the illumination that reached the pupil during each of the different tasks was measured, in lux, with a light meter.
*Results:* The four most common habitual tasks were computer use, reading, sewing and sports. A high intersubject variability was found in pupil diameter, working distance and illumination conditions while conducting the same task. Statistically significant differences were found between the in-office measured photopic and mesopic pupil diameters and those obtained while participants were conducting their habitual tasks in real life conditions (all $p < 0.001$).
*Conclusions:* Potential multifocal contact lens users may present with different ages, different jobs or hobbies and different preferences regarding lighting conditions and working distances. This results in different pupil size, even within the same task. This information may be critical when selecting a particular lens design and add power. Eye care practitioners are therefore advised to assess pupil diameter in real life conditions.


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**PALABRAS CLAVE**
Lentes multifocales;
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Visión simultánea;
Distancia de trabajo

**Diámetro pupilar, distancia de trabajo e iluminación durante la realización de tareas habituales. Implicaciones para el uso de lentes de contacto de visión simultánea en presbicia**

**Resumen**
*Objetivo:* Calcular la distancia de trabajo, el diámetro pupilar y la iluminación en situaciones de la vida real, en una muestra de participantes con presbicia, durante la realización de tareas habituales.
*Métodos:* En el estudio participaron un total de 59 sujetos con presbicia (de edades comprendidas entre 45 y 63 años), con diferentes perfiles ocupacionales. Primeramente, se preguntó a los participantes acerca de sus tareas habituales con la ayuda de un cuestionario ad hoc, tras el cual se determinó el diámetro pupilar fotópico y mesópico, durante la realización de la tarea. Igualmente, se evaluó el diámetro pupilar mientras los participantes realizaban cada una de las tareas habituales auto-reportadas, tomando una fotografía, a la que posteriormente se realizó un análisis de imagen. Además, se calculó la distancia de trabajo con una cinta métrica, además de medir, en lux, la iluminación que llega a la pupila durante cada una de las diferentes tareas.
*Resultados:* Las cuatro tareas más comunes y habituales fueron: uso del ordenador, lectura, costura y deportes. Se halló una variabilidad inter-sujetos en términos de diámetro pupilar, distancia de trabajo y condiciones de iluminación, durante la realización de la misma tarea. Se hallaron diferencias estadísticamente significativas entre los diámetros pupilares fotópico y mesópico medidos en el gabinete optométrico y aquéllos evaluados durante la realización de las tareas habituales en situaciones de vida real (todas las $p < 0.001$).
*Conclusiones:* Los potenciales usuarios de lentes multifocales presentan diferentes edades, diferentes trabajos o hobbies, y distintas preferencias, en relación a las condiciones de iluminación. Esto resulta en diferentes diámetros pupilares incluso al realizar la misma tarea. Esta información puede ser fundamental a la hora de seleccionar el diseño y la adición de una lente en particular, y añadir una potencia diferente. Por ello, se aconseja la evaluación del diámetro pupilar en las situaciones de la vida real, por parte de los profesionales de la salud visual.


## Introduction

With a prediction of 21% of the world population aged 60 years or older in 2050,[1] presbyopia may become one of the most pressing visual concerns of the 21st Century, particularly in developed countries in which visual demands for near and intermediate vision may be different late in life. Optical and refractive options for presbyopic patients are well documented.[2,3] Contact lenses for presbyopia are traditionally based on translation (mostly rigid gas permeable lenses) or simultaneous vision (mostly hydrogel or silicone-hydrogel materials) principles, with monovision offering an alternative for these patients.[4,5] Simultaneous vision relies on lens designs providing two or more foci through which incoming light from distant and near (and intermediate) objects falls on the retinal plane.[6]

For simultaneous vision to be effective, light energy distribution to the various foci must be similar, that is, pupil coverage for the distance and near (and intermediate) areas of the lens needs to be approximately the same, although some controversy exists regarding the extent of the deviations that still lead to operative simultaneous vision.[7–9] In fact, even those lens designs labeled as pupil independent, based on successive concentric distance and near vision regions, with spherical aberration providing a certain degree of intermediate vision, require a minimum pupil diameter to work.[9–11]

Success with simultaneous vision contact lenses is also influenced by age. Indeed, as presbyopia advances, patients require higher add powers for near vision, that is, larger power gradient across the lens surface.[12] Besides, pupil diameter tends to decrease with age, and with it the useful optic zone of the lens. Ocular spherical aberration becomes more positive with age,[13] although large inter-subject variations in spherical aberration have been reported.[14] The joint contribution of these factors leads to an increase in depth of focus which, in addition to the reported better tolerance to defocus in elder patients,[15] has been found to result in changes in the subjective depth of focus of about 0.027 D per year from the age of 21–50 years.[16]

Given the variety of simultaneous vision lens designs, contact lens practitioners base their lens selection on their knowledge of power distribution for each lens type (information not always provided by the manufacturer) and on the specific visual demands of their patients for distance, intermediate and near tasks. Successful multifocal contact lens fitting has been associated with the expertise of practitioners and with correct lens selection,[17] although even then contact lens dropout remains particularly high in this correction modality, with many patients reporting