Rebound tonometry for the measurement of intraocular pressure and its relation with gender and refractive errors in Mozambique

Aim: To evaluate the intraocular pressure (IOP) in the university student population in an urban region in Mozambique using rebound tonometry. **Methods:** A cross-sectional study with a random selection of students was conducted. IOP was measured after an optometric examination that included uncorrected visual acuity testing, static retinoscopy and subjective refraction without cycloplegia. Refractive error data were converted into spherical equivalent. IOP of the participants was assessed with the Icare® rebound tonometer (Tiolat Oy, Helsinki, Finland). **Results:** A total of 422 subjects (197 men and 225 women) between 17 and 26 years of age were examined. The mean value of IOP of the whole sample was 14.32 ± 3.30 mmHg. Statistically significant differences in IOP values were not found between men and women (p = 0.564) nor among refractive groups (p = 0.725). **Conclusion:** Rebound tonometry has been demonstrated to be a convenient and effective method for measuring IOP in this population. Icare can be considered as an adequate instrument for measuring IOP under the conditions of this population because it does not require much training, does not require an anesthetic and uses disposable probes, which is essential in countries with a high risk of transmission of infectious diseases.

KEYWORDS: developing countries ■ intraocular pressure ■ Mozambique ■ rebound tonometry

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There is a large list of methods for measuring intraocular pressure (IOP), but the Goldmann Applanation Tonometer (GAT) remains the 'gold standard' for clinical application since it was introduced more than 50 years ago [1]. Several methods and devices for measuring IOP have been developed to overcome the limitations of GAT, namely its relative invasive character and need for anesthetic and training. The great majority of devices that have been introduced in clinical practice have been compared against GAT in order to study their reliability and repeatability [2].

Rebound tonometry (RT) is being increasingly used. Some studies have compared the rebound tonometer Icare® (Tiolat Oy, Helsinki, Finland) with GAT, providing good repeatability and reliability [3–5]. At the same time, other tonometers that employ the RT, such the IOPen, have been analyzed and compared with the Icare, with the Icare being the tonometer that presented the higher accuracy for the measurement of IOP [6]. Thus, Icare can be considered as one of the most reliable and accurate methods for RT. Icare is a portable tonometer that allows rapid measurement of IOP without the need for topical anesthetic. A small disposable rod probe impacts the cornea and bounces back, the instrument detects this movement and gives the IOP value. Owing to the small size of the probes, Icare allows measurements in different areas of the cornea [7]. The relatively low cost and the easy and rapid measuring process with Icare makes this instrument a useful tool for optometric examinations in countries with poor medical assistance and where specialized personnel are very scarce. At the same time, disposability of the probes is a determinant advantage of this technique in a country that has a high risk of transmission of infectious diseases, as Mozambique does with a high prevalence of HIV [101].

The aim of this study was to report IOP values in a Mozambican, urban, university population and its relation with gender and refractive error. To the best of our knowledge this is the first study providing data about IOP values in Mozambique. We also aim to demonstrate the usefulness of RT and its advantages in measuring IOP in these populations.

Methods

The current study was carried out at the beginning of the 2008/2009 academic year, with a sample of 422 subjects (197 men and 225 women) between the ages of 17 and 26 years (23.00 ± 2.18 years). According to the estimations of Krejcie and Morgan [8], the sample represents the whole population of young-adult students of superior education that live in urban

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areas in Mozambique considering a population of 40,000 students in the surveyed age range. All the participants were recruited randomly.

Exclusion criteria from the study included previous or present eye disease, injury with repercussions in visual acuity or corneal physiology, and history of corneal surgery. Medical history, uncorrected visual acuity, fundus examination and external examinations were performed to discard these conditions. Two subjects were excluded from the study due to severe ocular infections with corneal affectation.

Local authorities (Instituto Superior de Ciências da Saúde de Maputo, Mozambique) gave their consent to conduct the study, as well as any individual participating in the study. All the participants signed an informed consent once all the methods, benefits and potential risks were explained. The tenets of the Declaration of Helsinki were followed in this study.

After the first part of the protocol for assessing inclusion criteria of the participants, every subject was subjected to an optometric examination. All measurements were performed by an experienced optometrist. Noncyclopegic static retinoscopy and noncycloplegic subjective refraction were conducted. Retinoscopy value was used as a starting point for the subjective refraction and was refined to reach the subject's best visual acuity [9]. Criterion of maximum plus best visual acuity was followed to determine the sphere. A cross-cylinder technique was used to accurately determine the axis and amount of astigmatism. Refractive error data were converted into spherical equivalent (M). The cut-off point was chosen at M = -0.50D (included) for myopia and +0.50D (included) for hyperopia. Emmetropia was considered from M >-0.50D and <+0.50D. This classification will be used for comparisons of IOP among different refractive groups.

After the optometric examination, IOP measurement was carried out with the portable rebound tonometer, Icare. The measurements of IOP with Icare were conducted in accordance with other studies [3,4]. Icare uses disposable probes. Each probe consists of a magnetized steel wire shaft covered with a round plastic tip at the end that minimizes the risk of corneal injury from the probe impact during the acquisition. Each subject was asked to look straight ahead to a far point while the examiner aligned the instrument near to the subject's eye. The distance from the tip of the probe to the cornea was 4–8 mm. Icare has a forehead support for adjusting the distance of the tonometer and the eye when necessary. When the patient was perfectly aligned with the instrument, the measurement button was pressed. The instrument takes six measurements consecutively and averages them to obtain the IOP value. Two valid series of six measurements were taken and the mean value of IOP was recorded as the average.

Data were analyzed using SPSS for Windows v.17.0 (SPSS Inc., Chicago, IL, USA). Normal distribution of variables was assessed using the Kolmogorov–Smirnov test. Owing to the lack of normality in the distribution of IOP values, nonparametric tests were used (Kruskal–Wallis and Mann–Whitney) to gauge any statistically significant difference in IOP data as a function of refraction and gender. Statistical differences were considered significant for $p < 0.05$.

Results

High correlation between the eyes (Spearman's Rho = 0.756) was present, hence only the right eye of each subject was used for subsequent analysis in order to avoid data duplication that could affect the significance of results [10].

The frequency distribution of IOP values for the whole sample is presented in Figure 1. The mean value of the IOP for the whole sample was 14.32 ± 3.30 mmHg. Extreme values of IOP were 28 mmHg (maximum) and 8 mmHg (minimum), however, the distribution of the IOP for this population showed that a great majority of the sample had values considered to be normal.

The mean value of IOP was 14.45 ± 3.54 mmHg for men and 14.21 ± 3.08 mmHg for women. Figure 2 shows IOP values distributed by gender. When IOP was compared between men and women, no statistically significant differences were found (Mann–Whitney, p = 0.564).

There was no correlation between refractive error and IOP (Spearman's rho = 0.07, p = 0.115). IOP values for different refractive groups are presented in Figure 3. The mean refractive error for the myopic, hyperopic and emmetropic group was -1.12 ± 1.08, +0.61 ± 0.15 and -0.07 ± 0.13D, respectively. Within the three refractive groups, despite the hyperopia group presenting with a slightly higher mean value for IOP, differences among refractive groups were not statistically significant (Kruskall–Wallis, p = 0.725).

Discussion

This study is the first to report values of IOP with a minimally invasive method in a Mozambican population. It shows that this approach could

be beneficial for improving visual health examinations by measuring IOP in countries such as Mozambique where the risk of transmission of infectious diseases is elevated, medical assistance is very scarce and the lack of trained staff precludes the realization of more complex examinations with other instruments such as the GAT.

Glaucoma is thought to be the second most common cause of blindness worldwide after cataracts [11–13]. It has been estimated that over 8.4 million people were bilaterally blind from primary glaucoma in 2010, and this figure is thought to rise to 11.1 million by 2020 [14]. These data highlight the relevance of early detection, affected population's controls and treatment of glaucoma. Glaucoma can be considered as a treatable disease with reduced consequences if detected early, however, if untreated it can lead to irreversible blindness.

Elevated IOP is the most common risk factor in populations affected by glaucoma and it has a high relevance in the great majority of studies owing to the direct relationship demonstrated [15,16]. Although there are different ongoing investigations that study the importance of other risk factors, the main goal for the treatment of this disease is still to decrease IOP [17]. Black race is considered one of the most important risk factor for glaucoma owing to higher levels of IOP in black populations compared with others [18,19]. Furthermore, several works that studied different risk factors and the relation with glaucoma have demonstrated that black populations globally have a higher risk for glaucoma than other populations [16,20–23].

In this study we present data of IOP values in a sub-Saharan population measured with the rebound tonometer, Icare. Our results in a black African population show a mean IOP value of 14.32 ± 3.30 mmHg, which can be considered within the normal range and that could be explained by the fact that this is a young population (17–26 years) without known ocular disease. Likewise, a large number of studies have demonstrated that black populations have thinner corneas than others, for example Caucasian or Asian [24,25]; and the fact that thicker corneas correlate with higher values of IOP if measured with the rebound tonometer Icare, as was reported by Jorge *et al.* [26], could be another explanation for interpretation of our results. However, we cannot attribute the relatively low IOP values to corneal thickness because we have not measured that parameter. Furthermore, there is some controversy over the influence of the properties of the cornea in the measurement of IOP with RT [27,28] and more studies should be carried out to clarify this situation. We would like to note that even though most of the participants in our study had IOP values within the normal range, some of them had an IOP of nearly 28 mmHg, which is well above the values considered normal. These patients were referred to an ophthalmologist in order to evaluate other clinical evidences and clarify if some pathology was presented.

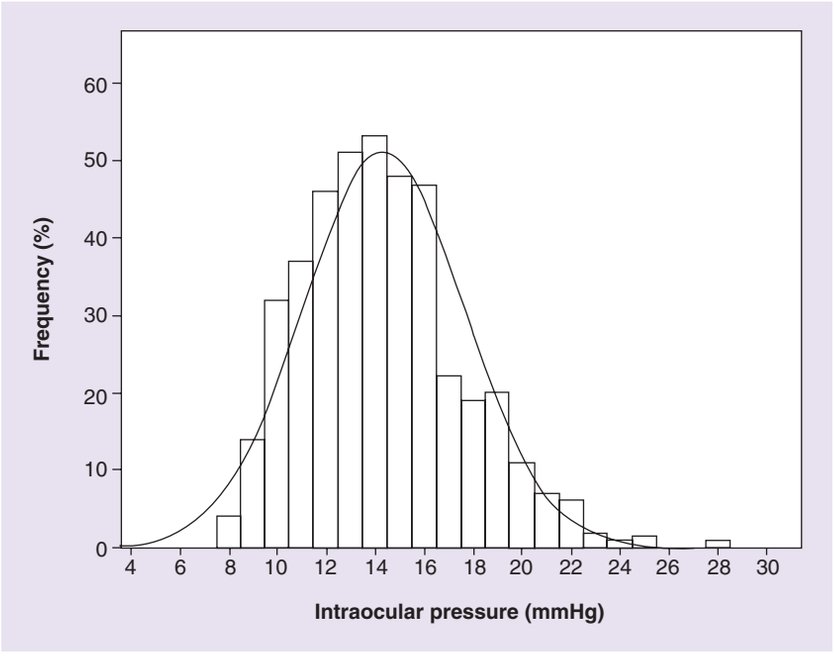

Figure 1. Distribution of intraocular pressure for the whole population (n = 422) expressed as mmHg.

As we mentioned before, IOP has been demonstrated to be an important risk factor of glaucoma. At the same time, higher levels of myopia have also demonstrated a direct relationship with higher prevalence of glaucoma [29,30]. Furthermore, in a recent study conducted by us in the same region, we found a higher level of myopia than expected for this region [31]. Even though the aim of our study was not to detect subjects affected by glaucoma, the research shows the relation of ocular hypertension as an important risk factor for glaucoma among refractive groups. No significant differences for IOP among refractive groups were found ($p = 0.727$). The absence of outliers and lesser variability between IOP values in the hypermetropic group (Figure 3) are due to the lower number of hypermetropic subjects in the total sample. Our results are in accordance with other studies. For example, in the Blue Mountains Eye Study, conducted by Mitchell *et al.*, they found that IOP was only 0.5% higher for myopic

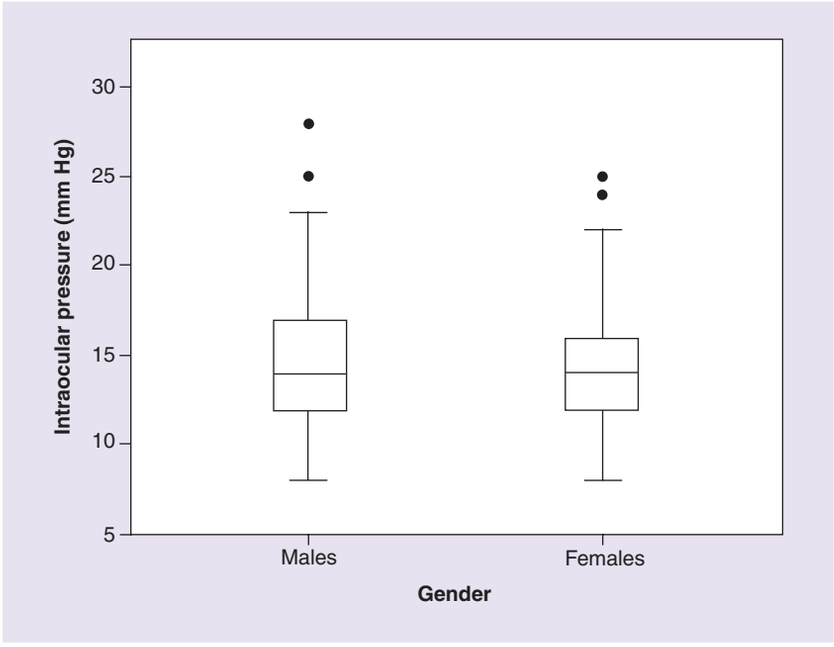

Figure 2. Intraocular pressure values (mmHg) as a function of gender.

than for nonmyopic eyes and they did not find a relationship between IOP and myopia. They defined higher intervals of refractive error for the definition of myopia [30]. Thus, taking into consideration their results and the mean refractive error of our myopic group (-1.12 ± 1.08D), it is possible that our results of myopia and IOP values are in accordance with this study. Furthermore, when IOP was compared among men and women, no statistically significant differences were found (p = 0.564). Different results have been found in other studies. For example, in a recent study by Medina-García *et al.*, differences between men and women were found, with slightly higher IOP values noted for men than women [32]. However, in their study there was a higher range of age (20–40 years). Therefore, owing to the small range of age in our study, it seems to be more difficult to find differences within both groups.

Despite the relatively low values of IOP and the lack of relationship between refractive error and IOP (r = 0.077, p = 0.115), it is necessary to perform better examinations and to continue with the monitoring of these populations as they get older, because age and refractive error, particularly if myopia prevalence also increases, along with their ethnic and genetic load, could place these people at a greater risk of visual health problems.

Mozambique is a country in which any disease is dramatically dangerous. In addition, specialized personnel in primary healthcare are very scarce. Both the risk of infectious diseases and the absence of competent healthcare services make it even more important that easy and aseptic devices are employed in the studies carried out in these regions. GAT is the gold standard for the clinical measurement of IOP since its appearance in clinical practice more than 50 years ago [1]. However, GAT presents a number of difficulties in its utilization and other methods have been developed and compared with GAT for overcoming these problems. Babalola *et al.* demonstrated the importance of an alternative method to GAT for measuring IOP to overcome difficulties in populations that live in places in which GAT is impossible to perform and that have a high risk of transmission of infectious diseases [24]. For example, hepatitis, herpex simplex virus or HIV and some ocular conditions such as adenoviral keratoconjunctivitis could be spread by the use of GAT without complete sterilization [33]. In fact, several studies have demonstrated in recent years the importance of sterilization of contact instruments in clinical practice [34,35].

Rebound tomometry is the method used for measuring IOP in this study, and has been compared recently with GAT and other methods [4,36,37]. The rebound tonometer Icare has demonstrated a slight overestimation of IOP values compared with GAT and good repeatability and reliability [3–5]. Furthermore, in a recent study by Jorge *et al.*, Icare and IOPen rebound tonometers were compared using GAT as a reference. Icare demonstrated a higher accuracy than IOPen for measuring IOP [6]. Thus, Icare remains the current most reliable and accurate method across the different methods for RT. Apart from these characteristics, the most important features of this rebound tonometer that we considered for this work were that it does not require an anesthetic, the easy and rapid method for taking measurements, the reduced cost compared with other noninvasive techniques and, above all, the elimination of cross-contamination risk among patients.

The results of our study show normal values for IOP in this young adult population. The authors suggest that studies measuring IOP in older populations should be concluded in this region. In addition, owing to the relative relationship between corneal properties and the results of RT, data on central corneal thickness should be considered in studies that include RT for measuring IOP.

A correct diagnosis of glaucoma depends on numerous clinical evidences based on other structures and variables beyond IOP.

However, some studies indicate that a simple control of the baseline IOP is a useful tool for monitoring glaucomatous progression over long-term follow-up [38]. The dramatic impact of glaucoma and the higher exposure of black populations to glaucoma should encourage clinicians to increase the number of studies for detecting and controlling more parameters in these regions, thus helping underprivileged black populations to avoid glaucomatous progression and the subsequent irreversible visual loss. As has been stated in this study, there are studies that have reported values of IOP measured with different methods in unprivileged populations [24], and over the last few years studies have been conducted that used RT with the aim of demonstrating the reliability of the instrument for measuring IOP [4,6,37]. However, no studies that have used RT have done so in populations and conditions similar to those in this work, thus it is difficult to compare our results with others owing to the substantial differences in the procedures employed. It would be useful to have other studies and results confirm the conclusions about RT found in our study.

Despite the limitations of this study, which included the low age of the population and the relatively low values of IOP, the conclusions showed that RT is a useful method for measuring IOP in the absence of specialized personnel and in populations at high risk of transmission of infectious diseases. Furthermore, we would like to highlight that this study presents the first data on IOP measured with RT in a sub-Saharan population and is the first report of data of IOP values in Mozambique, establishing a valuable profile from which to develop future studies.

Conclusion

The search for easy, low cost, accurate and noninvasive technologies is one of the most important objectives of the massive screening programs. Screening programs in unprivileged regions are needed as there is a lack of information in the most part of developing regions. Without data on the status of visual health in these regions, the focus of developing programs for improving health systems would be unclear and ineffective.

Future perspective

One of the challenges for the future is to have databases of the visual health status of unprivileged regions. Within the aims of having databases of these regions, programs also need to be developed that help these populations receive the correct level of support and treatment. Taking into account the impact of IOP as a risk factor of glaucoma on visual health, the control of this parameter is an important issue for future programs. A greater number of studies in these regions is key to helping to improve the situation.

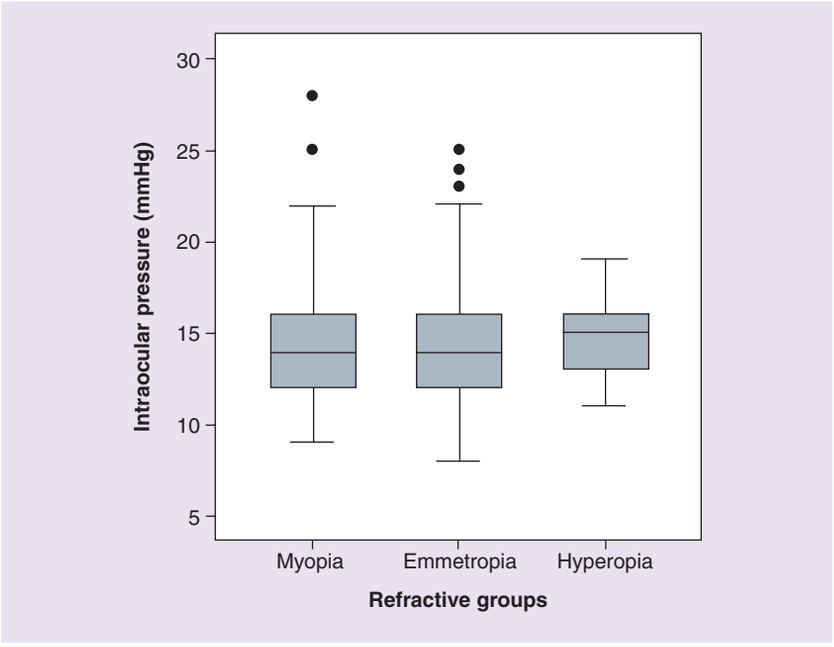

Figure 3. Intraocular pressure values (mmHg) among refractive groups.

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Ethical conduct of research

The authors state that they have obtained appropriate institutional review board approval or have followed the principles outlined in the Declaration of Helsinki for all human or animal experimental investigations. In addition, for investigations involving human subjects, informed consent has been obtained from the participants involved.

Executive summary

- Values of intraocular pressure in students from an urban region of Mozambique can be considered within the normal range for the age of the population under analysis.
- Screenings are of interest to increase knowledge of the health status of a population.
- Not all the methods employed in developed regions can be used in the developing countries.
- In countries with a high risk of transmission of infectious diseases, the use of hygienic methods is crucial.
- Icare® can be considered adequate for screening of intraocular pressure under the conditions of this population because it does not require much training, does not require an anesthetic and uses disposable probes.

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