The Change in Intra-ocular Pressure Following Application of Ice to the Eye

By

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Introduction

Scientists and doctors have examined many ways to lower the intraocular pressure (IOP) in humans in their battle against glaucoma. Most research concerning lowering IOP has centered on the use of topical medications to increase outflow of aqueous or to decrease aqueous production. It is known that IOP fluctuates throughout the day and exercise and general health play a role in maintaining good IOPs. However, to our knowledge the affects of external temperature on IOP have never been investigated. We sought to find out if external temperature, in particular icing outside surface of the eye, had any affect on the IOP.

Procedure and Result

Twenty-three subjects were chosen for the study (12 males and 11 females). Preliminary Goldman tonometry readings were taken on each of the patients' eyes. The subjects were then instructed to place a bag of ice over the eye of their choice for five minutes. The other eye served as the control. They were asked to hold their hand against the control eye for that same amount of time in an attempt to negate the decrease in IOP due to aqueous being forced from the eye. Once the ice was removed from the eye, tonometry readings were taken on both eyes. The first measurement was immediately following the five minutes that the stimuli were applied to the eyes. Five more readings were performed with a time interval of five minutes between measurements. Anesthetic and fluorescein were added as needed. The same instrument was used to take the readings to avoid any variability.

The results of the eyes receiving the ice are listed in Table 1. The results of the control eyes are shown in Table 2. The averages of all the subjects' results over time are listed along the bottom row of each of the tables. Table 1 shows an average preliminary reading of 14.15mmHg. Immediately following the removal of the ice, the average temperature showed a drop of 4.04mmHg. Over the next half-hour, the readings remained below the preliminary by 2.32mmHg to 3.22mmHg. Table 2 shows an average preliminary reading of 14.28mmHg. A drop of 2.48mmHg was seen once the subjects removed their hand from the control eye. The next half-hour again showed lower pressures ranging from 1.00mmHg to 1.30mmHg below their starting pressure. These averages are represented graphically in Table 3 (Series 1 shows the results of the eye receiving the ice treatment and series 2 shows the results of the control eye). Both eyes show decreases from the starting pressure, but the eye receiving the ice treatment shows more of a decrease.

Subject number 4 showed marked differences between the two eyes. His starting pressure was at 13mmHg in the eye that received the ice. After five minutes a 5.5mmHg drop in pressure was recorded. The next half-hour showed a rise to 10mmHg, which is 3mmHg below the beginning pressure. The control eye showed a preliminary pressure of 14mmHg. The pressure in that eye varied between 14 and 15mmHg, never going below the starting pressure (See tables 1 and 2).

Subject number 6 also showed a significant difference between the two eyes. The eye receiving the ice had a beginning pressure of 13mmHg. After five minutes of experiencing the ice, a drop of 6mmHg was noted. Pressures from 8.5 to 10mmHg were seen over the remaining time. Again, the pressure did slowly rise, but it was still 3mmHg below the preliminary pressure. The control eye had a beginning pressure of 12mmHg. After the five minutes, of having their hand over their eye, a 2mmHg decrease in pressure was seen. The pressure in that eye varied between 10 and 12mmHg over the remaining time (See tables 1 and 2).

Subject number 12 had preliminary pressures of 16mmHg in both eyes. The eye with the ice showed a 6.5mmHg drop in pressure. The eye receiving equal pressure but no ice showed a drop of 4mmHg. Over the remaining time, the eye that had the ice treatment varied between 2.5 and 5.5mmHg below its starting pressure. The control eye varied between 13 and 17mmHg (See tables 1 and 2).

Subject number 13 had a preliminary pressure of 19mmHg in the eye that got the ice treatment. A drop of 5mmHg was seen once the ice was removed from the eye. The pressures ranged between 14 and 18mmHg for the remaining time. The control eye showed a 4mmHg drop in pressure, once the stimulus was removed. Over the next half-hour, the pressure varied between 16 and 21mmHg. It is interesting to note that the pressure between the two eyes was consistently lower in the eye receiving the ice by an average of 2mmHg (See tables 1 and 2).

Subject number 18 had starting pressures of 16mmHg in both eyes. After the five minutes of having the stimuli on the eyes, the eye undergoing the ice treatment showed a drop of 6mmHg and the control eye showed a drop of 5mmHg. The following readings showed that the control eye quickly went up towards its initial pressure, whereas the having received the ice slowly went up (varying between 11 and 15mmHg). The control eye varied between 15 and 17mmHg. Again the eye that had the ice placed over it showed lower readings than the control eye (See tables 1 and 2).

Some patients did not show any significant differences between the two eyes. Subject number three had a starting pressure of 10.5mmHg in the eye receiving the ice and ranged anywhere from 9.5 to 12mmHg, over the next half-hour. The control eye had a starting pressure of 10mmHg and ranged between 10 and 11.5mmHg. Subjects number ten, eleven, and twenty-two barely showed any variability between the eye that had undergone the treatment with the ice and the control eye (See tables 1 and 2).

Even though there appears to be a wide variability between one individual and another, the average results indicate that a lowering of pressure did occur in both eyes. The eye undergoing the treatment with the ice showed a greater initial drop in pressure than the control eye, once the stimuli were removed. Throughout the remaining time, the eye that received the ice showed lower pressures than the control eye, yet both remained below the initial pressure.

The data was also separated into initial pressures below 15mmHg and pressures of 15mmHg and up (See table 4). The pressures that were 15mmHg and greater showed an average initial drop of 5mmHg between the preliminary reading and the reading taken immediately after the removal of the ice. The preliminary average was 16.31mmHg. The next half-hour showed average readings of 11.31, 12.81, 12.69, 13.81, 13.62, and 13.56mmHg. These readings were at least 2.5mmHg below the starting pressure. Pressures less than 15mmHg showed an average initial drop of 3.54mmHg between the preliminary reading and the measurement taken once the ice was removed from the globe. The preliminary average was 13.00mmHg. The average readings over the next half-hour were 9.46, 9.93, 10.23, 10.76, 10.76, and 10.40. These measurements were at least 2.24mmHg below the starting pressure. Both groups showed big drops once the stimuli were removed and remained well below the preliminary measurement during the remaining measurements. Table 5 is a graphic representation of what happened to the pressures among the two groups (series 1 shows subjects with initial pressures of 15mmHg and higher and series two shows subjects with initial readings of less than 15mmHg).

The data was also separated into male and female to see if sex played any significant role in pressures (See table 6). The top half of the table shows the data for the females and the bottom half shows the data for the males. The eleven females showed an average preliminary pressure of 14.68mmHg. Their average pressure once the ice was removed was 3.77mmHg lower. Pressures of 11.77, 12.04, 12.72, 12.59, and 11.91mmHg followed. The males had an average preliminary pressure of 13.66mmHg. Their average pressure once the treatment with the ice was stopped was 4.29mmHg less than the preliminary. Pressures of 10.17, 10.21, 11.00, 11.00, and 11.13mmHg were observed over the next half-hour. A graphic representation of the data can be seen in Table 7 (Series 1 represents the data for the females and series two represents the data for the males). The graphs appear to be very similar in their slopes. The males do appear to have lower measurements after the treatment with the ice, but they also had lower preliminary pressures.

One source of experimental error could be due to the fact that it was difficult to quantify the amount of pressure applied to both eyes. Some subjects may have been holding the ice and their hand firmly against the globe, whereas others may not. Also the amount of pressure applied between an individuals eyes may also not have been equal. Mire thickness may also play a role in pressures being higher or lower then the true amount. Diurnal variations in intraocular pressure could also contaminate the data (the measurements were not taken at the same time of day). The same slit lamp and Goldman tonometer were used, but the instrument itself may not be calibrated correctly. Human error in determining the exact position of the mires may also be another cause of experimental error leading to faulty data. Ideally we should have used an impartial clinician to take IOP measurements to avoid possible skewed results but time and availability were difficult issues to overcome.

<u>Discussion</u>

It appears that cold temperatures do result in a significant decrease in intraocular pressure on average. When looking at each subjects' data separately, some showed significant decreases, some moderate, and some none at all. When the data was sorted by pressure, individuals with higher pressures seemed to show more of a decrease as compared to subjects with lower pressures. When the data was looked at to see if there was any sex predication no significant differences were found. It was interesting that the pressure in the control eye also showed a decrease, even though it was less of a decrease than the treated eye. Pressure against the globe may also be playing some sort of role in decreasing the intraocular pressure.

We postulate that the IOP reduction is caused by the decreased enzymatic activity produced by the lower temperature within the ciliary body. It is known that decreases in temperature cause enzymes to slow and become less productive. It is also known that the major cellular force in aqueous production is active transport, not ultra-filtration as was once thought. Consequently, the enzymes used in the production and secretion of aqueous may be slowed, resulting decreased aqueous in the anterior chamber and thus lowering IOP.

Conclusion

While the results of this study are promising it is obvious that more research is necessary in order to fully understand and appreciate the effects of lower temperatures on IOP. We feel that further research is worth while because this form of therapy may offer a cheap, easy means for treating the various forms of glaucoma. Although it is unlikely that this therapy could be used as the alone to treat glaucoma it may be of great benefit if used as an adjunct to topical medications.

Table 1

	Pre	5 min	10 min	15 min	20 min	25 min	30 min
PT 1	16	13	12	13	14	14	14
PT 2	16	10	12	12.5	15.5	13.5	14.5
PT 3	10.5	9.5	10.5	12	11	10	9
PT 4	13	7.5	8	9.5	10	9	10
PT 5	16.5	11	12	11	11	12	12
PT 6	13	7	8.5	9.5	10	10	10
PT 7	14	8	12	10	10	9.5	10.5
PT 8	14	10	10	10	12	12	11.5
PT 9	14	11	11	12	13	13	10
PT 10	14	13	14	15	14	14	12
PT 11	16	15	16	15	15	17	16
PT 12	16	9.5	10.5	13	13	13	10
PT 13	19	14	16	17	18	17	14
PT 14	14	10	12	10.5	12	11.5	12
PT 15	12	10	9.5	10	11	10	9
PT 16	13	10	8	9	8	9.5	9
PT 17	12	6	6.5	7	8	7	8
PT 18	16	10	13	11	14	12.5	15
PT 19	15	8	11	9	10	10	13
PT 20	13.5	10	10.5	10	11	12	10
PT 21	12	9	8.5	8.5	11	10	11
PT 22	12	10	10	10.5	9.5	11.5	11
PT 23	14	11	10	10	11	12.5	13
TOTAL	325.5	232.5	251.5	255	272	270.5	264.5
AVG	14.15	10.11	10.93	11.09	11.83	11.76	11.5

Table 2

	Pre	5 min	10 min	15 min	20 min	25 min	30 min
PT 1	14	13	14	14	13.5	13.5	15
PT 2	17	12	14	14	15.5	14	15
PT 3	10	11.5	10	10	10	10	10
PT 4	14	14.5	14.5	14	15	14	14
PT 5	18	14	12	16	14	14	15
PT 6	12	10	10.5	12	10	12	11
PT 7	14	12	16	12	11	12	12.5
PT 8	16	13	14	14	12	13	13.5
PT 9	13	8	11	11	12	11	10
PT 10	14	12	14	15	13	14	14
PT 11	16	15	17	15	17	17	17
PT 12	16	12	15	15	17	14	13
PT 13	20	16	18	20	21	18	16
PT 14	15	12	14	13	14	13	12
PT 15	13	12	10.5	12	13	12	10
PT 16	13	10	10	12	11.5	12	13
PT 17	12	8	8	8	11	13	10
PT 18	16	11	16	15	16	15	17
PT 19	14	8	11	11	12	12	14
PT 20	13.5	14	13	12	11.5	15	12
PT 21	12	10	12	12	12.5	11	14
PT 22	13	10.5	11	11	10.5	11.5	11
PT 23	13	13	13	14	12.5	13	14
TOTAL	328.5	271.5	298.5	302	305.5	304	303
AVG	14.28	11.8	12.98	13.13	13.28	13.22	13.17

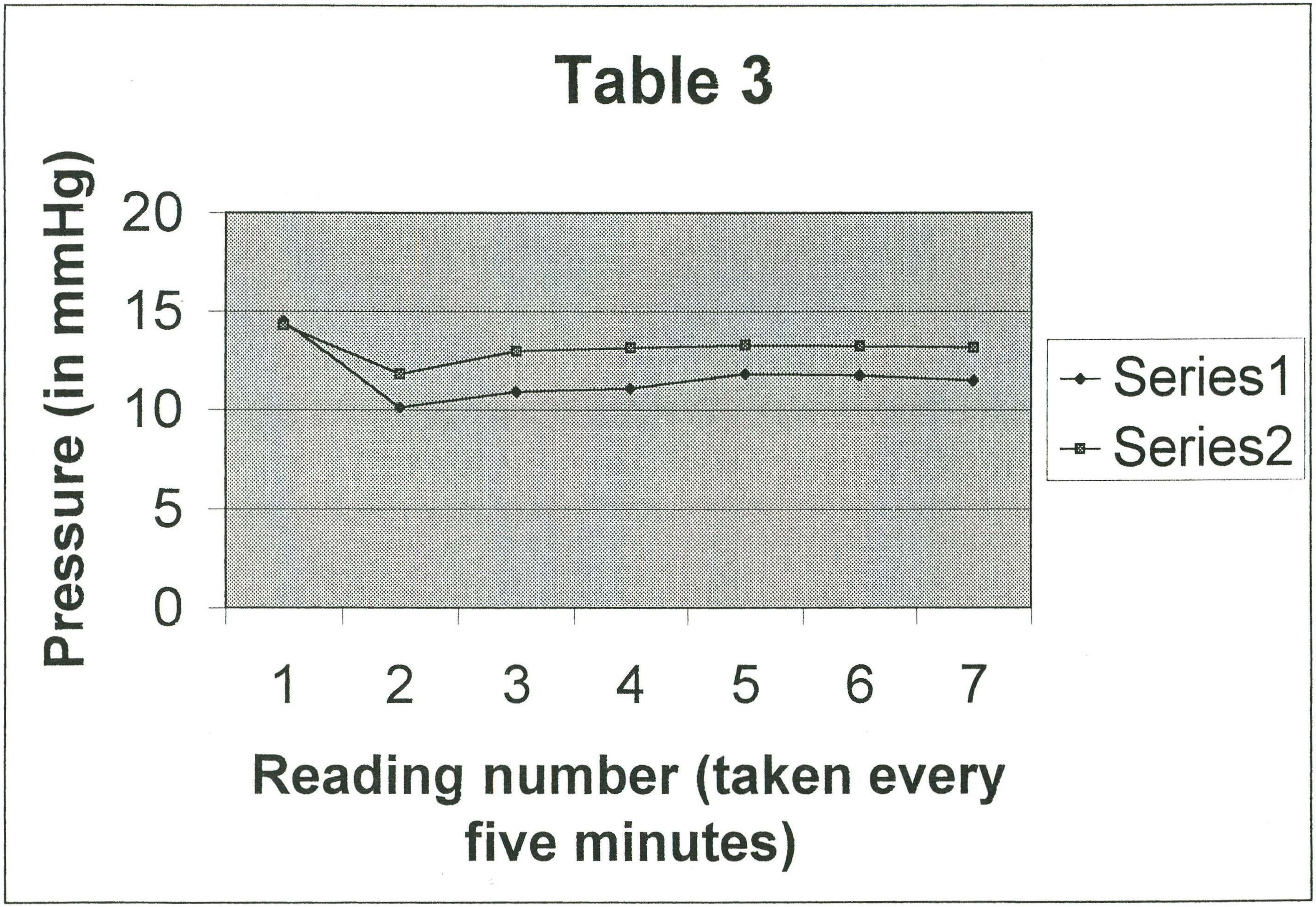


Table 3
Pressure (in mmHg)
20
15
10
5
0
1
2
3
4
5
6
7
Reading number (taken every five minutes)
Series1
Series2

TABLE 4

	PRE	5 MIN	10 MIN	15 MIN	20 MIN	25 MIN	30 MIN
SUBJ 1	16	13	12	13	14	14	14
SUBJ 2	16	10	12	12.5	15.5	13.5	14.5
SUBJ 5	16.5	11	12	11	11	12	12
SUBJ 11	16	15	16	15	15	17	16
SUBJ 12	16	9.5	10.5	13	13	13	10
SUBJ 13	19	14	16	17	18	17	14
SUBJ 18	16	10	13	11	14	12.5	15
SUBJ 19	15	8	11	9	10	10	13
TOTAL	130.5	90.5	102.5	101.5	110.5	109	108.5
AVG	16.31	11.31	12.81	12.69	13.81	13.62	13.56

	PRE	5 MIN	10 MIN	15 MIN	20 MIN	25 MIN	30 MIN
SUBJ 3	10.5	9.5	10.5	12	11	10	9
SUBJ 4	13	7.5	8	9.5	10	9	10
SUBJ 6	13	7	8.5	9.5	10	10	10
SUBJ 7	14	8	12	10	10	9.5	10.5
SUBJ 8	14	10	10	10	12	12	11.5
SUBJ 9	14	11	11	12	13	13	10
SUBJ 10	14	13	14	15	14	14	12
SUBJ 14	14	10	12	10.5	12	11.5	12
SUBJ 15	12	10	9.5	10	11	10	9
SUBJ 16	13	10	8	9	8	9.5	9
SUBJ 17	12	6	6.5	7	8	7	8
SUBJ 20	13.5	10	10.5	10	11	12	10
SUBJ 21	12	9	8.5	8.5	11	10	11
SUBJ 22	12	10	10	10.5	9.5	11.5	11
SUBJ 23	14	11	10	10	11	12.5	13
TOTAL	195	142	149	153.5	161.5	161.5	156
AVG	13	9.47	9.93	10.23	10.76	10.76	10.4

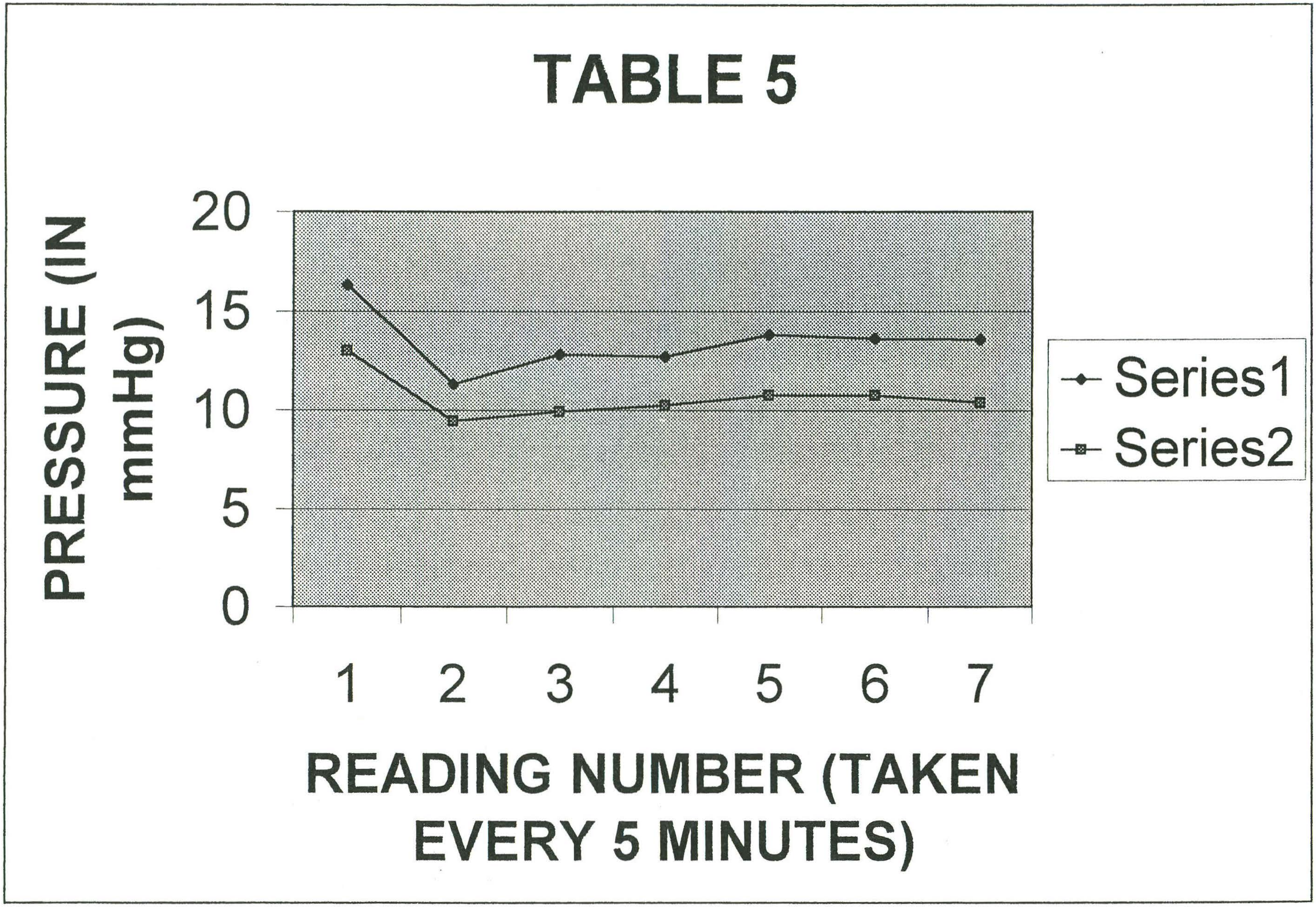


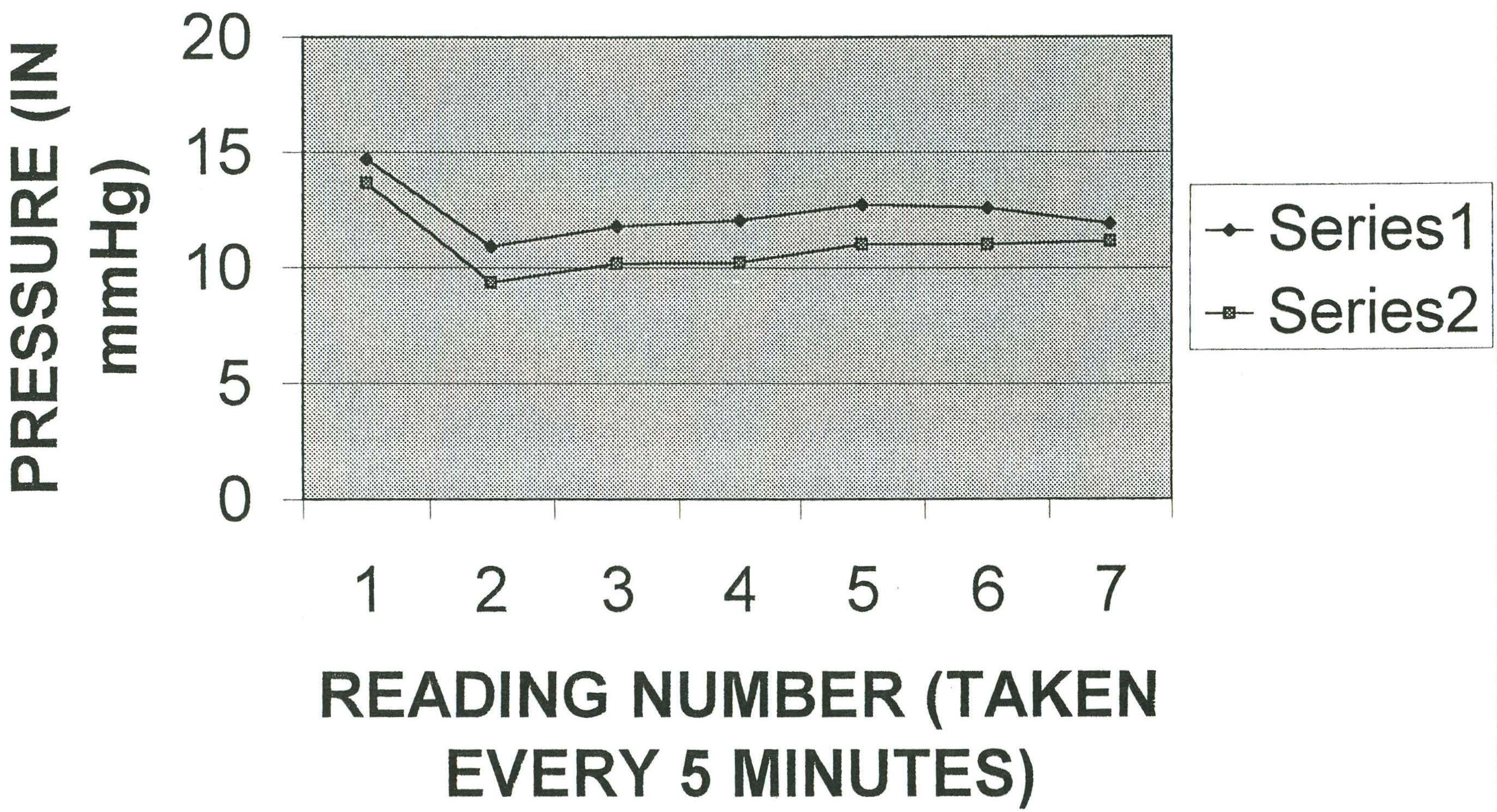
TABLE 5
PRESSURE (IN mmHg)
20
15
10
5
0
Series1
Series2
1
2
3
4
5
6
7
READING NUMBER (TAKEN EVERY 5 MINUTES)

TABLE 6

	PRE	5 MIN	10 MIN	15 MIN	20 MIN	25 MIN	30 MIN
SUBJ 1	16	13	12	13	14	14	14
SUBJ 3	10.5	9.5	10.5	12	11	10	9
SUBJ 5	16.5	11	12	11	11	12	12
SUBJ 10	14	13	14	15	14	14	12
SUBJ 11	16	15	16	15	15	17	16
SUBJ 12	16	9.5	10.5	13	13	13	10
SUBJ 13	19	14	16	17	18	17	14
SUBJ 17	12	6	6.5	7	8	7	8
SUBJ 18	16	10	13	11	14	12.5	15
SUBJ 20	13.5	10	10.5	10	11	12	10
SUBJ 21	12	9	8.5	8.5	11	10	11
TOTAL	161.5	120	129.5	132.5	140	138.5	131
AVG	14.68	10.91	11.77	12.05	12.73	12.59	11.91

	PRE	5 MIN	10 MIN	15 MIN	20 MIN	25 MIN	30 MIN
SUBJ 2	16	10	12	12.5	15.5	13.5	14.5
SUBJ 4	13	7.5	8	9.5	10	9	10
SUBJ 6	13	7	8.5	9.5	10	10	10
SUBJ 7	14	8	12	10	10	9.5	10.5
SUBJ 8	14	10	10	10	12	12	11.5
SUBJ 9	14	11	11	12	13	13	10
SUBJ 14	14	10	12	10.5	12	11.5	12
SUBJ 15	12	10	9.5	10	11	10	9
SUBJ 16	13	10	8	9	8	9.5	9
SUBJ 19	15	8	11	9	10	10	13
SUBJ 22	12	10	10	10.5	9.5	11.5	11
SUBJ 23	14	11	10	10	11	12.5	13
TOTAL	164	112.5	122	122.5	132	132	133.5
AVG	13.67	9.38	10.17	10.21	11	11	11.13

TABLE 7


PRESSURE (IN mmHg)
20
15
10
5
0
1
2
3
4
5
6
7
READING NUMBER (TAKEN EVERY 5 MINUTES)
Series1
Series2

References

1) Adler's Physiology of the Eye: Clinical Application / edited by William J. Hart, Jr. – 9th edition. Mosby Year Book, Chicago, 1985.
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