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A Comparative and Interrelationship Study between Blood Pressure and Intraocular Pressure in Young Healthy Male Adults after Water Ingestion

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ABSTRACT

Background: Oral water ingestion increases blood volume, and hence blood pressure (BP) which in turn increases intraocular pressure (IOP). The aim of the present study was to know the interrelationship between BP and IOP of both the sides, before and after water ingestion, in young healthy male subjects.

Methods: This is a comparative and interrelationship study for which thirty six male subjects aged 17- 20 years were selected. BP of both arms was recorded every 15 minutes and IOP was recorded every 30 minutes for two hours in both control and study trials (before and after water ingestion respectively). Statistical analysis was done using Student's t test and regression analysis.

Results: Water ingestion led to a significant increase in BP and IOP of both eyes. Significant correlation was present between mean arterial pressure (MAP) and IOP on right side in both trials. But, there was no correlation between MAP and IOP on left side in both trials.

Conclusion: It can be concluded that correlation between BP and IOP, before and after water ingestion is not uniform on both sides, whose cause cannot be clearly explained and therefore, needs further in depth study of the underlying anatomical and physiological processes.

Keywords: *Water ingestion, blood pressure, intraocular pressure, mean arterial pressure, normal eyes*

Introduction

Oral water ingestion increases blood volume, and hence blood pressure (BP)[1] which in turn increases intraocular pressure (IOP). [2, 3] Studies regarding interrelationship between water ingestion and IOP[2], blood pressure and IOP [3, 4] are available in literature. But, there is no data available which compares the interrelationship between IOP and BP of the respective sides, and also after water ingestion. In view of this, the present study was undertaken to know the interrelationship between IOP and BP, on both the sides, in apparently healthy individuals after water ingestion (i.e. 2% of body weight water intake, approximately 1000 ml).[5]

Material and Methods

This is a comparative study analyzing the effect of water ingestion on IOP and BP and also a study of the interrelationship between these parameters in young healthy male adults in the age group of 17 to 20 years.

The study was conducted on 36 first MBBS students. Informed consent was obtained from each of the student. Ethical clearance was obtained from the institution. The same set of students were chosen for a control trial (before water ingestion) as well as for a study trial (after water ingestion), in order to avoid the confounding factors. Only apparently healthy male students with emmetropia were included in the study. Subjects with refractive errors, history of ocular trauma or ocular surgery were excluded.

Data was collected in the research laboratory during early morning hours (8.00 AM to 11.00 AM) daily.

Anthropometric parameters like height in centimeters and weight in kilograms were recorded.

All parameters were recorded in lying down position.

During the control trial, IOP of both the eyes was recorded in lying down position by indentation method at every 30 minutes for 2 hours under aseptic precautions after instillation of xylocaine eye drops, using Schiotz tonometer. Blood pressures of both arms were recorded simultaneously by auscultatory method every 15 minutes up to 2 hours using mercury sphygmomanometer (Diamond).

Later, during the study trial, the student was asked to consume water (2% of his body weight) over a period of 5 min. Again, IOP of both the eyes and blood pressure of both the arms were recorded at similar intervals by the above mentioned procedure.

Mean Arterial Pressure was calculated by the formula:

Diastolic Blood Pressure + 1/3 Pulse Pressure

(Pulse pressure = Systolic blood pressure – Diastolic blood pressure)

Statistical analysis was done by using SPSS soft ware version 9.0 under the guidance of a biostatistician. All the values were presented as mean ± standard deviation. Comparison of mean values of parameters between the two trials (control and study) was done by paired t test and correlation between IOP and BP, at various intervals was done by Spearman's test. P value < 0.05 was taken as significant.

Results

The mean age of the subjects was 18.36 ± 0.833 (range 17 to 20 years), the mean height (cm) was 170.94 ± 4.99 and the mean weight (kg) was 59.88 ± 10.19.

Systolic blood pressure (SBP):

Comparison of study trial with control trial

Right arm SBP: There was a steady increase in SBP in study trial which was significant at 15, 30 and 45 minute intervals as compared to control trial.

Left arm SBP: There was no significant change in SBP in study trial as compared to control trial (Table 1).

Diastolic blood pressure (DBP):

Comparison of study trial with control trial

Right arm DBP: This showed a significant increase in study trial as compared to control trial at all intervals.

Left arm DBP: This showed a significant increase in study trial as compared to control trial at 15 to 45 minute intervals ($P<0.05$) (Table 2).

Mean arterial pressure (MAP):

Comparison of study trial with control trial

Right arm MAP: This showed a significant increase by about 3 mmHg in study trial as compared to control trial ($P<0.05$).

Left arm MAP: This showed a significant increase at 15 and 30 minute intervals by about 3 mmHg in study trial as compared to control trial. ($P<0.05$) (Table 3).

Intraocular pressure:

Comparison of study trial with control trial

Right eye IOP: There was a significant increase by about 1mmHg at 60 minute interval in study trial as compared to control trial.

Left eye IOP: There was a significant increase by about 1mmHg at 30 minute interval in study trial as compared to control trial (Table 4).

Correlations between MAP and IOP:

Correlations of Right MAP and Right IOP in Control Trial at Different Intervals

There is a direct correlation between right MAP and right IOP at all intervals (at 30 min interval is shown in Figure 1).

Correlations of Left MAP and Left IOP in Control Trial at Different Intervals

No correlation found between left MAP and left IOP.

Correlations of Right MAP and Right IOP in Study Trial at Different Intervals

There is a significant direct correlation between right MAP and right IOP at all intervals.

Correlations of Left MAP and Left IOP in Study Trial at Different Intervals

No correlation found between left MAP and left IOP.

Discussion

In the present comparative and interrelationship study, the effects of water ingestion (i.e. well hydrated state) in study trial and the effects without water ingestion (i.e. comparative dehydrated state) in control trial on blood pressure and IOP were compared amongst male adults of 17-20 years of age.

Blood pressure: In the present study, there was an increase in the blood pressure (SBP, DBP and MAP) in study trial in comparison with control trial. SBP increased by about 2-5 mm Hg, DBP increased by about 7 mm Hg and MAP increased by about 6mm Hg from the basal value.

Several studies have been done to know the effect on BP with 480 to 500ml of water drinking only. Drinking of 500 ml of water increased supine SBP insignificantly from 118 ±2 to 119 ±2 mmHg. DBP also significantly increased from 70±2 to 73±2 mmHg.[1] The findings of the present study correlates with the above study but, does not correlate with the study done by Jens Jordan [6], in which, 480 ml of water drinking, did not produce significant change in blood pressure in younger controls but, in older healthy controls, SBP increased to 11± 2.4 mm Hg after 35 minutes of water drinking and also Scott EM [7], in which, no significant changes were observed in MAP/or DBP following water ingestion. These differences in the findings could be because of more amount of water ingested (2% of body weight) within a span of 5 minutes in the present study. Water ingestion of 2 % body weight causes increased absorption of water within 15 minutes so as to increase the blood volume which in turn causes increase in blood pressure and IOP. [5]

Intraocular Pressure: In the present study, there was a significant transient increase in IOP ($p<0.05$) by about 1 mm Hg in both eyes in study trial at 30 minute interval. A transient increase in IOP was also found by Moura[8] after water ingestion. A transient increase in aqueous production and slightly elevated IOP can be induced by rapid ingestion of fluid (water-drinking test) in an eye with normal aqueous out flow. [2]

Interrelationship between BP and IOP: A positive linear relationship of IOP with MAP and also with DBP at all intervals in right arm of both study and control trials was observed in the present study. A 1 mm Hg increase in IOP in both eyes was observed for every 2-5 mm Hg increase in SBP, 7 mm Hg increase in DBP and 4-6 mm Hg increase in MAP of both right and left arms.

In a cross- sectional population based study the mean IOP of both eyes increased linearly from 14.3 mm Hg for systolic BP < 110 mm Hg to 17.7 mm Hg for systolic BP < 200 mmHg. [3] In a five year follow - up study of systemic blood pressure and IOP, a significant direct correlation between changes in systemic BP and changes in IOP was observed. There was a 0.21 mm Hg increase in IOP for a 10 mm Hg increase in systolic BP and 0.43 mm Hg increase in IOP for 10 mm Hg increase in DBP.[4] In a study on 9 normal subjects, and 10 autonomic failure subjects, analysis of co-variance indicated a strong association (covariance) between MAP and IOP overall.[9] But, in another study, systolic

blood pressure was more closely correlated with intraocular pressure[10], which was contradictory to the present study, wherein mean blood pressure was more correlated with IOP, the reason for this difference could be the age difference of the subjects in these two studies. Subjects with an IOP > 20 mm Hg had a significantly higher systolic blood pressure than age matched controls. Comparison of the differences in blood pressures for cases of elevated IOP and matched controls suggested that SBP was 6.20 mm Hg higher in cases than in controls. Changes in IOP were positively correlated with changes in SBP and DBP over both 1 & 2 years period.[11] Schulzer and Drance [12], in their study, observed that the diastolic pressure neither correlated with IOP nor with age. Larger correlations were observed between maximum IOP and systolic BP than between maximum IOP and mean BP.

Our observations of an increase in IOP may be due to an increase in MAP, DBP and SBP, along with blood volume changes associated with 2% body weight water ingestion.

It can be concluded that the correlation between BP and IOP, before and after water ingestion is not uniform on both the sides. The cause cannot be clearly explained and therefore, needs further in depth study.

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Conflict of Interests: None to declare

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Table 1: Systolic blood pressure of right and left arms in control and study trials

Time	Control trial		Study trial	
	Right arm SBP(mmHg)	Left arm SBP(mmHg)	Right arm SBP(mmHg)	Left arm SBP(mmHg)
0 min	117.72 ±9.88	119.83 ±9.69	117.44 ±9.85	118.22 ±10.83
15 min	115.44 ±9.74	118.5 ±9.98	122.05* ±8.78	119.77 ±10.07
30 min	115.61 ±9.85	117.83 ±9.20	121.55* ±8.12	119.16 ±10.36
45 min	115.88 ±9.64	118.5 ± 9.49	120.5* ±7.39	117.77 ±9.15
60 min	115.61 ±9.28	118.27 ±9.35	119.22 ±9.14	118.16 ±8.82
75 min	115.94 ±9.35	118.22 ±9.25	117.66 ±8.30	117.55 ±8.97
90 min	115.61 ±9.43	118.27 ±9.19	117.33 ±8.32	117.38 ±8.77
105 min	115.61 ±9.43	118.38 ±9.11	117.11 ±8.10	116.83 ±8.17
120min	115.50 ±9.60	118.22 ±9.10	117.38 ±8.22	116.94±8.21

* p Value < 0.05.

Table 2: Diastolic blood pressure of right and left arms in control and study trials

Time	Control trial		Study trial	
	Right arm DBP(mmHg)	Left arm DBP(mmHg)	Right arm DBP(mmHg)	Left arm DBP(mmHg)
0 min	75.22 ±10.06	78.66 ±8.88	79.00* ±8.27	77.77 ±9.95
15 min	75.83 ±8.93	79.72 ±8.66	85.05* ±7.14	83.44* ±8.52
30 min	75.44 ±9.62	79.88 ±7.92	86.00* ±8.34	84.22 *±8.03
45 min	75.61 ±8.94	79.27 ±8.64	83.33* ±9.34	83.00* ±8.45
60 min	76.16 ±8.53	79.63 ±9.14	81.55* ±9.21	82.27 ±8.64
75 min	76.05 ±8.50	79.22 ±8.84	81.00* ±8.06	80.77 ±8.51
90 min	76.16 ±8.44	79.33 ±8.99	79.94* ±7.86	80.44 ±8.05
105 min	76.16 ±8.44	79.22 ±8.85	79.05* ±7.44	79.27 ±8.03
120min	76.16 ±8.44	79.16 ±8.76	79.00* ±7.41	79.38 ±7.95

* p Value < 0.05. .

Table 3: Mean arterial pressure of right and left arms in control and study trials

Time	Control trial		Study trial	
	Right arm MBP(mmHg)	Left arm MBP(mmHg)	Right arm MBP(mmHg)	Left arm MBP(mmHg)
0 min	89.38±8.69	92.38±8.52	91.81*±7.59	91.35±9.58
15 min	89.03±8.01	92.64±8.60	97.38*±6.89	95.55*±8.37
30 min	88.83±8.49	92.53±7.83	97.85*±7.68	95.86*±8.01
45 min	89.03±8.12	92.35±8.44	95.72*±8.14	94.49±7.87
60 min	89.31±7.64	92.31±8.58	94.11*±8.20	94.24±7.88
75 min	89.35±7.71	92.22±8.44	93.22*±7.44	93.03±8.21
90 min	89.31±7.67	92.31±8.49	92.4*±7.29	92.75±7.71
105 min	89.31±7.67	92.23±8.41	90.74±9.03	91.79±7.60
120 min	89.27±7.73	92.18±8.31	91.79*±6.98	91.9±7.58

* p Value < 0.05. .

Table 4: IOP of right and left eye in control and study trials

Time	Control trial		Study trial	
	Right IOP(mmHg)	Left IOP(mmHg)	Right IOP(mmHg)	Left IOP(mmHg)
0 min	16.76±3.15	16.96±2.44	17.03±2.11	16.96±2.69
30 min	16.19±3.18	16.41±2.68	17.04±2.75	17.76*±2.88
60 min	15.69±2.79	16.3±2.57	16.3*±2.49	16.08±2.61
90 min	15.43±2.90	15.61±2.70	15.88±2.2	15.85±2.18
120 min	15.43±2.90	15.61±2.7	15.89±1.98	15.75±2.07

* p Value < 0.05.

Figure 1: Correlation of right MAP and right IOP in control trial at 30 minute interval