International Journal on
Eternal Wisdom and Contemporary Science

Volume 1 • Issue 1 • June 2024 • pp 75-88

Effect Of Yoga On Hemorheological Parameters Of Blood And Their Connection With Health

Dr. S.K. Pathak
Ph.D in Biomedical Engineering, Indian Institute of Technology, Bombay, India
under the guidance of
Prof. (Retd.) P. Chaturani
Mathematics Dept., Indian Institute of Technology, Bombay, India

Abstract:

Many diseases, including some mental ones, are observed to be cured by yoga. Besides an overall improvement in physical and mental health, the practice of yoga is also believed to improve the immunity of the individual. The aim of this paper is to identify the hemorheological parameters of blood which can be used as indicators of physical and mental health, and to show the qualitative and quantitative effect of yoga on these parameters.

A sample of 16 subjects was considered. They were taught preliminary yoga and they practiced yogic exercises everyday (for about 1 hour) for 50 consecutive days. Their early morning (fasting) blood samples were collected, before starting the yogic exercise course as well as after the 50 days of yogic exercise. Hemorheological parameters (whole blood viscosity, red cell aggregation, red cell rigidity) of the subjects were measured by contravas LS30 viscometer at eighteen different shear rates. It was observed that yogic exercise had a significant influence on blood viscosity factors. A drop in aggregability and rigidity of red cells and apparent viscosity at different shear rates was observed. The subjects also reported that they felt much better, physically and mentally, after the 50 days of yogic exercise course. It can therefore be concluded that the well-being is connected with hemorheological parameters of blood and yoga can positively impact these factors.

Keywords: Yoga, Blood Viscosity, Hemorheological Parameters

INTRODUCTION

Yoga improves individual's physical, mental and spiritual capabilities [1]. It is believed that yoga works on different systems of body and improves their functioning. For instance,

- Cleansing processes remove toxin materials from the body [2].
- Asanas provide relaxed muscles [3] which in turn demands less blood supply to muscles [4] and hence the load on the heart is reduced.
- Pranayam improves breathing pattern which helps in providing better oxygenated blood to organs and muscles, reducing lactic acid formation [5]

The hemorheological parameters of the blood can be measured and be used as an indication of physical health. e.g. viscosity of blood, which plays a very important role in maintaining good circulation of blood to all parts of the body, is one such indicator.

While it is generally believed that there are no quantitative measures of mental stress and emotional disturbance, it has been observed that hemorheological parameters change significantly and adversely under emotional disturbance and mental tensions [6,7,8].

Yoga acts on both body and mind [9]. We can therefore assume that the comprehensive effect of yoga, on both mental as well as physical well-being, should be exhibited in terms of improved hemorheological parameters.

In the present work, an effort is made to study the effect of preliminary yogic practices on an individual's health, by measuring hemorheological parameters of blood. Such an approach to study the impact of yoga on overall health of individuals is an objective approach rather than a questionnaire based survey which can be very individual specific and subjective.

APPROACH

An exploratory survey was conducted to find out whether yoga practicing people have any specific features, regarding hemorheological parameters, in comparison to non-yoga practicing people. Comparison was made between the persons of same age, sex and habits. It was observed that in general (1) whole blood viscosity, (2) plasma viscosity and (3) red cell rigidity were less in yoga practicing people as compared to people who are not practicing yoga.

A survey of few yoga institutions was done and their methodology was studied. Ghantali Mitra Mandal, an institute for yoga in Thane, was chosen for recruiting the participants/subjects. This organization conducted two months preliminary course for beginners and it followed the same holistic yoga approach as Vivekananda Kendra, Bangalore, a world-renowned yoga institution.

Aspirants have to report every day in the morning for one hour yoga practice. Subjects were recruited from this preliminary course conducted by Ghantali Mitra Mandal.

PROCEDURE

Blood samples were collected from 16 subjects, on the first day of the course. They were collected early in the morning after making sure that each subject was fasting with only moderate water consumption prior to sample collection. This ensured standardization of the samples. Vials for collection of blood were filled with 0.15 ml of anticoagulant solution (E.D.T.A.) to prevented blood clotting for 6-7 hours. Samples were gently agitated before use.

Experiments on samples were conducted within 5 hours of collection of blood. Contravas LS30 viscometer was used to obtain the viscosity at 18 different shear rates. The blood was filled in capillaries for finding out hematocrit. Some blood was filled in test tubes to separate plasma and cells by putting in centrifuge for 10 minutes at 15000 rpm. Plasma viscosity was measured for 3 shear rates only. All the viscosity measurements were taken at 37°C. The temperature was maintained by circulating bath.

The samples were again collected after 50 days of yoga practice, to analyze the changes in the hemorheological parameters during this period.

RESULTS

Whole blood viscosity variation with different shear rates, before and after Yogic practice course has been given in Tables (1-4), and represented as viscosity I and II respectively. Variation of this viscosity with shear rate along with comparisons, before and after yogic practices are shown in Figs. (1-4).

It is observed from Tables (1-4) and Figs. (1-4) that after 50 days of Yoga practice, the blood viscosity at low shear rates is considerably reduced (maximum change observed is 54%). Since low shear rate viscosity is an indication of aggregability of red cells [10] (viscosity at low shear rate (0.51/sec) gives aggregability when standardized to 45% hemotocrit level [11]), it appears that one can control red cell aggregation with yogic practices.

It is of interest to note that five of the sixteen subjects (subject nos. 2, 8, 10, 13 and 16) did not show desirable change in viscosity at lower shear rate. A careful case study of these individuals showed that:

- Subject No. 2: Blood sample of this subject, before yoga course, was partially hemolysed. Presence of few crushed cells reduces viscosity and hence viscosity before yoga is less.

- Subject No. 8 and 10: Change was relatively small. We looked into both subject's case history, however, nothing significant could be identified.

- Subject No. 13: The blood sample after yoga course was partially hemolysed. This sample was, therefore, not considered in finding maximum % change in viscosity at low shear rate.

- Subject No. 16: Very insignificant change in blood viscosity at low shear rates (as a matter of fact at shear rate 0.512 per sec., viscosity increased 5%). A careful look at his case history revealed that this subject had some heart problem, therefore, was not advised cleansing processes and some other practices.

It is further observed from Tables (1- 4) and Figs.(1 - 4) that 50 days yogic course has brought down marginally whole blood viscosity at high shear rate (maximum change 17%). It may be noticed that the blood viscosity at higher shear rate gives a measure of rigidity of red cells [10,11]. Therefore, it may be concluded that yogic practices have some correlation with the reduction of red cell rigidity.

It is of interest to note that subject no. 6 had a good reduction of blood viscosity at low shear rate (reduction in red cell aggregability, Table 2 and Fig. 2b) but rigidity of red cells (blood viscosity at high shear rate) did not change significantly. While going through his case history, it was observed that he was an elderly person of 56 years and he had a lot of mental tension (regarding his daughter's marriage). This indicates some correlation of mental tension with cell rigidity.

It is further noticed that subject no. 4 was a young person and he had already been practicing yoga since few months, hence relatively very little change in viscosity was observed at all shear rates.

Subject no. 14 had recently undergone some operation, therefore could not do cleansing process, asanas and some breathing exercises. In addition to this, she had some depression problem. She could do only meditation and relaxation part of yogic course. It is of interest to note that there is no major change in blood viscosity at low shear rate (aggregability). However, there is a reasonable response at high shear rate.

TABLE 1: Viscosity before and after yoga, at 18 Shear rates for subject nos. 1, 2, 3 and 4

Shear rate	Subject No. 1		Subject No. 2		Subject No. 3		Subject No. 4	
	Vis I	Vis II	Vis I	Vis II	Vis I	Vis II	Vis I	Vis II
0.512	40.80	30.60	16.58	17.85	31.88	24.23	26.78	20.40
0.695	32.83	27.20	15.95	15.95	26.26	20.64	23.45	17.82
0.945	26.91	22.77	14.49	13.11	22.08	17.25	20.01	15.87
1.285	22.86	19.30	12.19	11.18	18.80	14.73	17.27	14.22
1.747	19.02	16.04	10.82	9.70	16.04	13.06	14.55	12.31
2.37	16.23	14.30	9.35	8.80	13.75	11.55	12.93	11.00
3.23	13.94	12.32	8.28	7.88	12.32	9.49	11.11	9.90
4.39	12.33	10.70	7.58	6.84	10.70	8.47	9.96	9.06
5.96	10.93	9.62	6.78	6.23	9.51	7.54	8.85	8.09
8.11	9.73	8.76	6.19	5.71	8.60	6.91	7.96	7.48
11.02	8.70	7.76	5.74	5.27	7.87	6.22	7.28	6.87
14.98	7.79	7.13	5.35	4.87	7.18	5.70	6.66	6.39
20.4	7.10	6.53	4.99	4.58	6.59	5.31	6.08	5.92
27.7	6.51	6.02	4.65	4.32	6.07	5.00	5.59	5.55
37.6	5.51	5.60	4.40	3.97	5.60	4.58	5.15	5.04
51.2	5.65	5.38	4.17	3.90	5.24	4.44	4.74	4.83
69.5	5.33	5.01	4.01	3.71	4.91	4.21	4.46	4.54
94.5	5.05	4.64	3.83	3.55	4.61	4.00	4.17	4.29

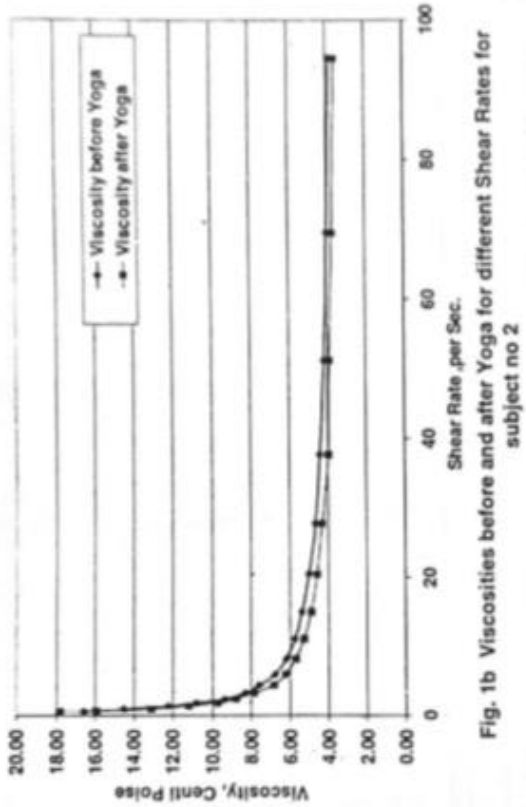

Fig. 1b Viscosities before and after Yoga for different Shear Rates for subject no 2

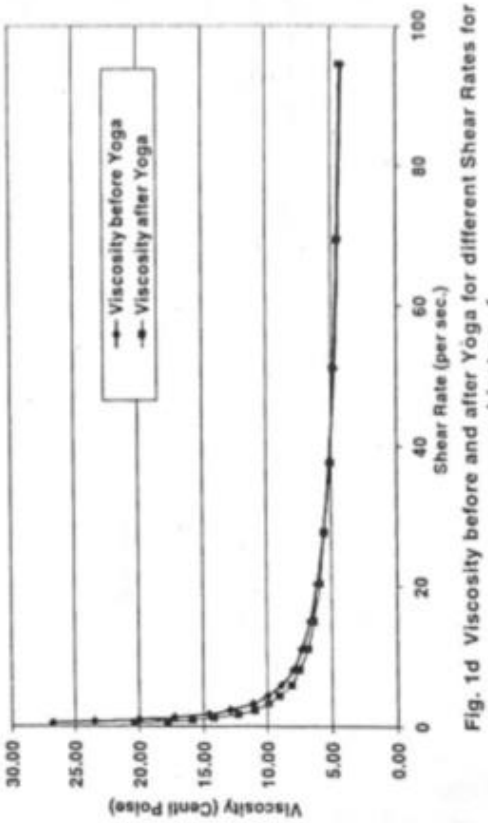

Fig. 1d Viscosity before and after Yoga for different Shear Rates for subject no. 4

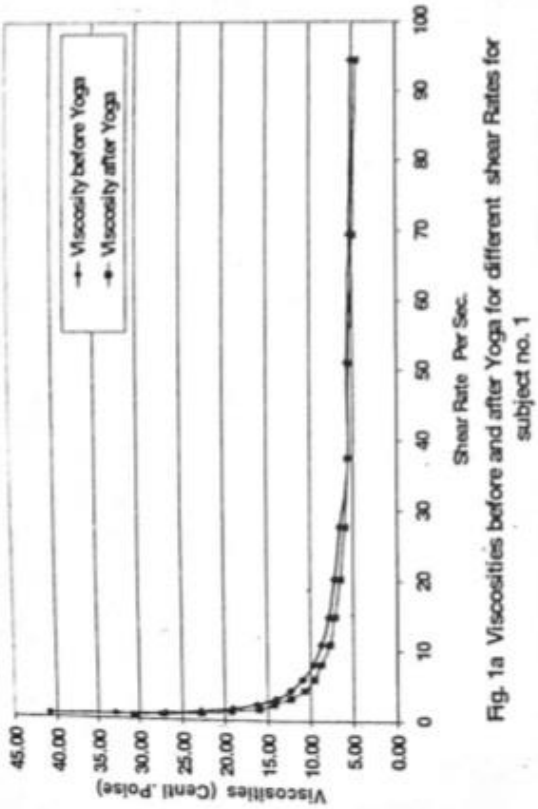

Fig. 1a Viscosities before and after Yoga for different shear Rates for subject no. 1

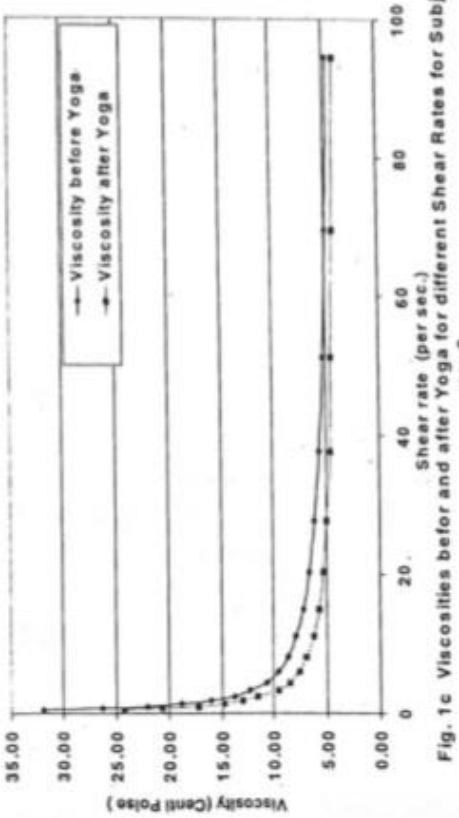

Fig. 1c Viscosities befor and after Yoga for different Shear Rates for Subject no. 3

TABLE 2: Viscosity before and after yoga, at 18 Shear rates for subject nos. 5, 6, 7 and 8

Shear rate	Subject No. 5		Subject No. 6		Subject No. 7		Subject No. 8	
	Vis I	Vis II	Vis I	Vis II	Vis I	Vis II	Vis I	Vis II
0.512	33.15	17.85	30.60	17.85	26.78	22.95	19.13	17.85
0.695	27.00	15.01	26.26	15.95	24.39	21.57	15.95	15.95
0.945	22.77	12.42	22.08	13.80	21.39	18.63	14.49	13.80
1.285	18.29	11.18	18.80	12.70	18.29	16.26	13.21	12.19
1.747	15.29	9.33	15.67	10.82	16.04	14.17	11.94	10.82
2.37	13.20	8.25	13.20	9.63	13.48	12.10	10.73	9.63
3.23	11.31	7.27	11.72	8.48	12.32	10.91	9.70	8.48
4.39	10.10	6.39	10.40	7.73	10.85	9.36	9.06	7.43
5.96	8.96	5.68	9.29	7.10	9.62	8.53	8.31	6.67
8.11	7.88	5.31	8.28	6.43	8.60	7.56	7.64	6.03
11.02	7.16	4.80	7.52	6.04	7.81	6.93	7.10	5.56
14.98	6.57	4.44	6.83	5.66	7.22	6.18	6.53	5.13
20.4	6.02	4.16	6.27	5.38	6.75	5.76	6.08	4.77
27.7	5.55	3.92	5.78	5.10	6.28	5.33	5.69	4.48
37.6	5.20	3.10	5.37	4.77	5.89	5.03	5.37	4.02
51.2	4.55	3.56	5.05	4.70	5.55	4.72	5.09	4.04
69.5	4.77	3.45	4.76	4.54	5.26	4.61	4.84	3.92
94.5	4.60	3.33	4.49	4.33	5.02	4.24	4.64	3.74

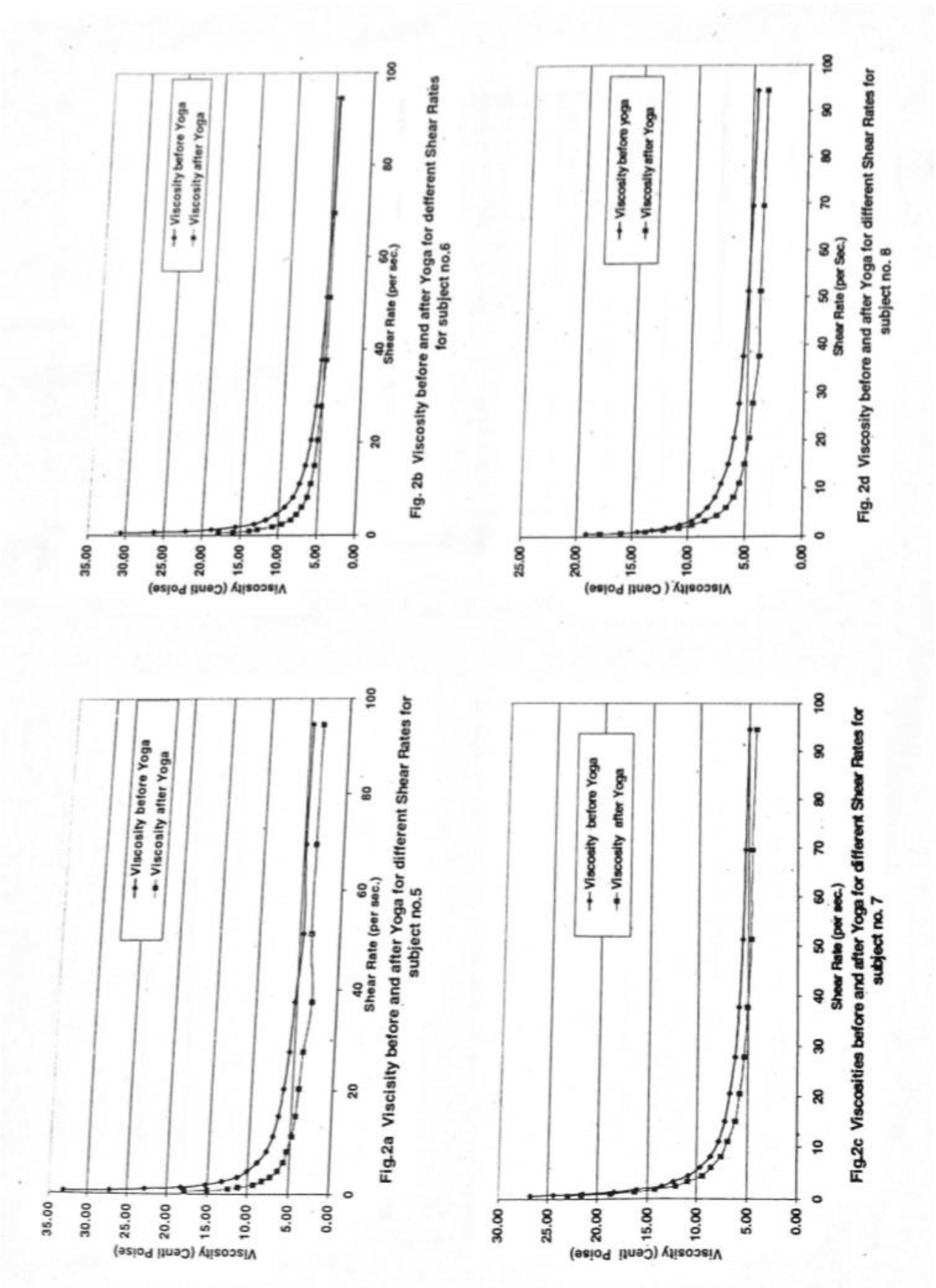

Fig. 2b Viscosity before and after Yoga for defferent Shear Rates for subject no.6

Fig. 2d Viscosity before and after Yoga for different Shear Rates for subject no. 8

Fig.2a Viscisity before and after Yoga for different Shear Rates for subject no.5

Fig.2c Viscosities before and after Yoga for different Shear Rates for subject no. 7

TABLE 3: Viscosity before and after yoga, at 18 Shear rates for subject nos. 9, 10, 11 and 12

Shear rate	Subject No. 9		Subject No. 10		Subject No. 11		Subject No. 12	
	Vis I	Vis II	Vis I	Vis II	Vis I	Vis II	Vis I	Vis II
0.512	31.88	20.40	34.43	31.88	20.40	15.30	24.23	19.13
0.695	27.20	16.88	27.20	24.39	17.82	14.07	19.70	16.88
0.945	22.77	15.18	23.46	21.39	15.87	13.80	16.56	13.80
1.285	19.81	13.21	20.83	18.80	13.72	11.18	13.72	11.68
1.747	17.16	11.56	17.53	15.67	11.94	9.70	11.56	9.70
2.37	14.85	10.18	15.13	13.75	10.73	8.53	10.18	8.25
3.23	12.93	8.89	13.13	11.51	9.49	7.88	8.69	7.07
4.39	11.44	8.02	11.59	10.40	8.77	7.13	7.73	6.24
5.96	10.38	7.21	10.38	9.18	7.98	6.56	7.00	5.57
8.11	9.33	6.67	9.25	8.20	7.32	6.03	6.19	5.07
11.02	8.41	6.22	8.35	7.40	6.75	5.62	5.62	4.61
14.98	7.74	5.79	7.57	6.53	6.22	5.18	5.13	4.05
20.4	7.14	5.41	6.94	5.95	5.76	4.83	4.70	3.71
27.7	6.63	5.03	6.37	5.43	5.38	4.51	4.34	3.33
37.6	6.15	4.63	5.86	5.11	5.03	4.18	4.07	3.28
51.2	5.70	4.39	5.38	4.60	4.73	4.00	3.91	3.07
69.5	5.38	4.15	5.08	4.31	4.49	3.66	4.16	3.35
94.5	5.10	3.93	4.78	4.01	4.29	3.53	4.04	3.26

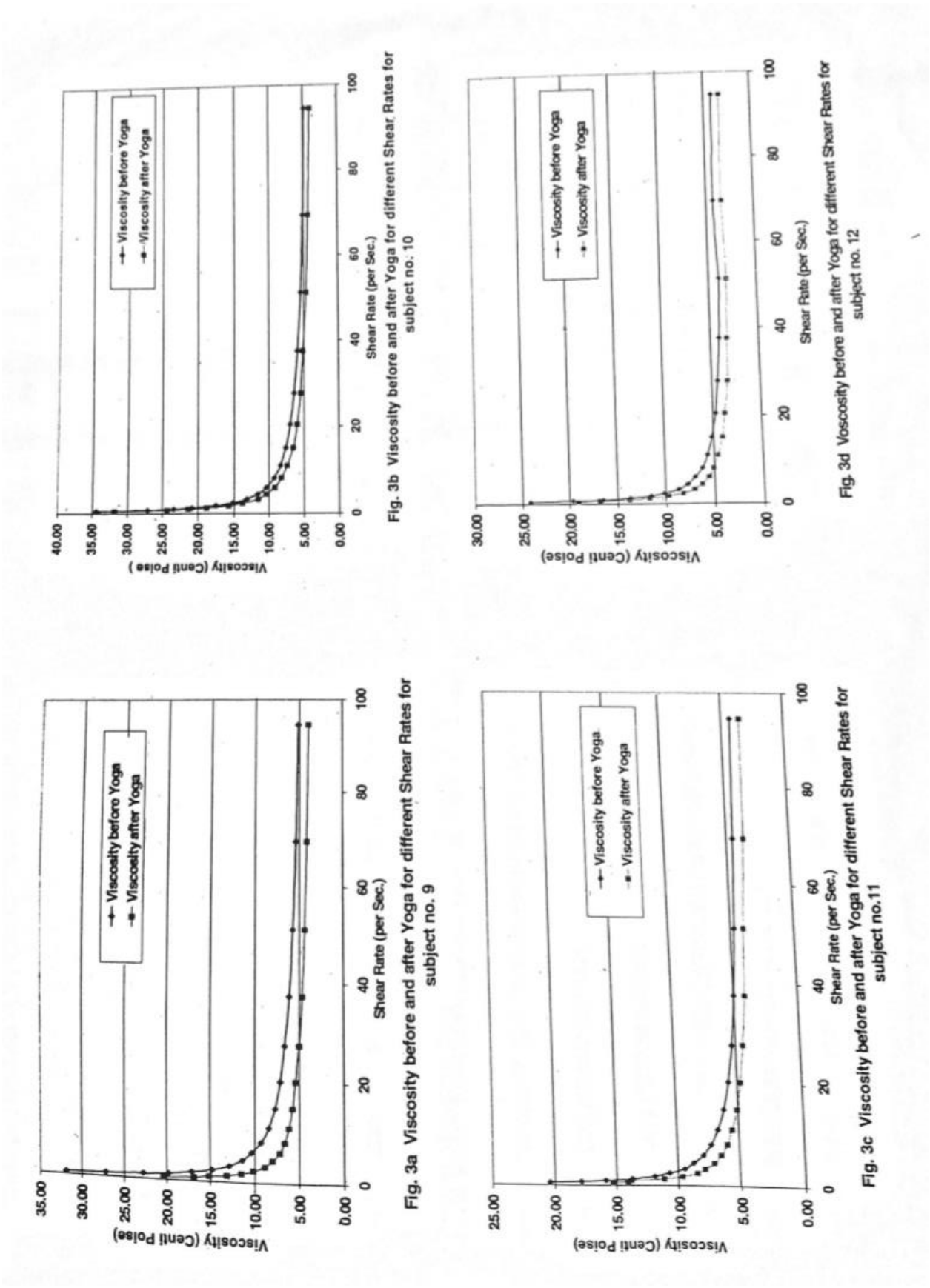

Fig. 3a Viscosity before and after Yoga for different Shear Rates for subject no. 9

Fig. 3b Viscosity before and after Yoga for different Shear Rates for subject no. 10

Fig. 3c Viscosity before and after Yoga for different Shear Rates for subject no.11

Fig. 3d Voscosity before and after Yoga for different Shear Rates for subject no. 12

TABLE 4: Viscosity before and after yoga, at 18 Shear rates for subject nos. 13, 14, 15 and 16

Shear rate	Subject No. 13		Subject No. 14		Subject No. 15		Subject No. 16	
	Vis I	Vis II	Vis I	Vis II	Vis I	Vis II	Vis I	Vis II
0.512	24.23	8.93	21.68	20.40	35.70	21.68	21.68	22.95
0.695	19.70	7.50	17.82	16.88	28.14	18.76	18.76	17.82
0.945	16.56	7.59	15.18	15.87	24.15	16.56	15.18	15.18
1.285	13.72	7.11	13.21	13.21	21.34	14.73	12.70	12.70
1.747	11.56	6.34	11.19	11.19	17.90	12.68	11.56	10.82
2.37	10.18	6.05	10.18	9.08	15.68	11.55	9.90	9.35
3.23	9.09	5.45	8.89	8.28	13.94	10.50	8.69	8.08
4.39	8.02	5.05	8.17	7.43	12.33	9.36	7.88	7.43
5.96	7.21	4.59	7.54	6.56	11.04	8.53	7.00	6.56
8.11	6.43	4.26	6.83	5.79	9.97	7.88	6.35	5.95
11.02	5.80	3.97	6.28	5.33	9.06	7.22	5.86	5.33
14.98	5.31	3.78	5.70	4.87	8.31	6.66	5.44	4.83
20.4	4.93	3.52	5.25	4.45	7.58	6.02	5.09	4.48
27.7	4.60	3.37	4.86	4.06	6.89	5.48	4.77	4.20
37.6	4.40	3.15	4.54	3.74	6.33	4.75	4.44	3.55
51.2	4.11	3.20	4.30	3.66	5.85	4.87	4.28	3.75
69.5	4.35	3.14	4.24	3.53	5.43	4.56	4.08	3.56
94.5	4.32	3.14	4.15	3.42	5.06	4.31	3.88	3.44

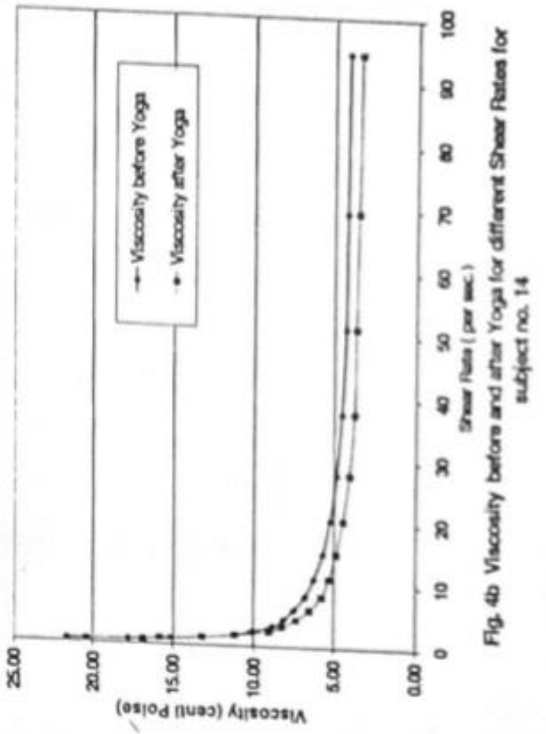

Fig. 4b Viscosity before and after Yoga for different Shear Rates for subject no. 14

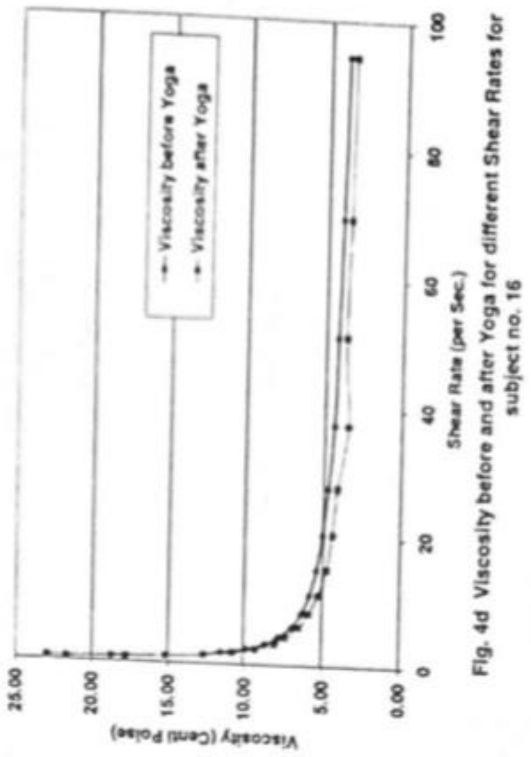

Fig. 4d Viscosity before and after Yoga for different Shear Rates for subject no. 16

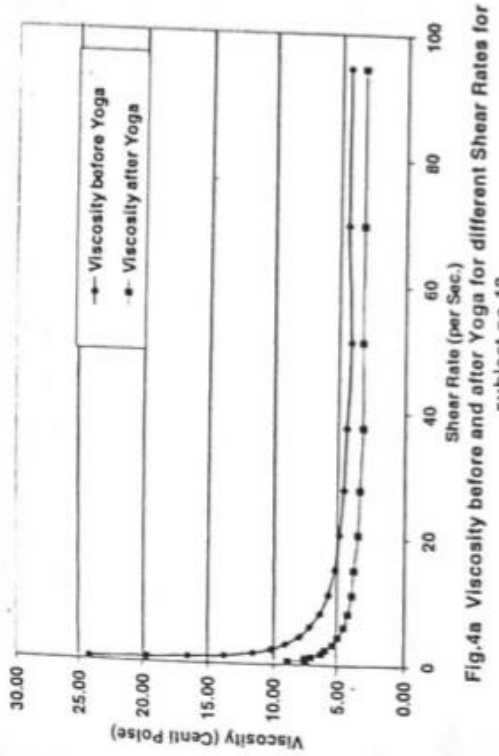

Fig.4a Viscosity before and after Yoga for different Shear Rates for subject no.13

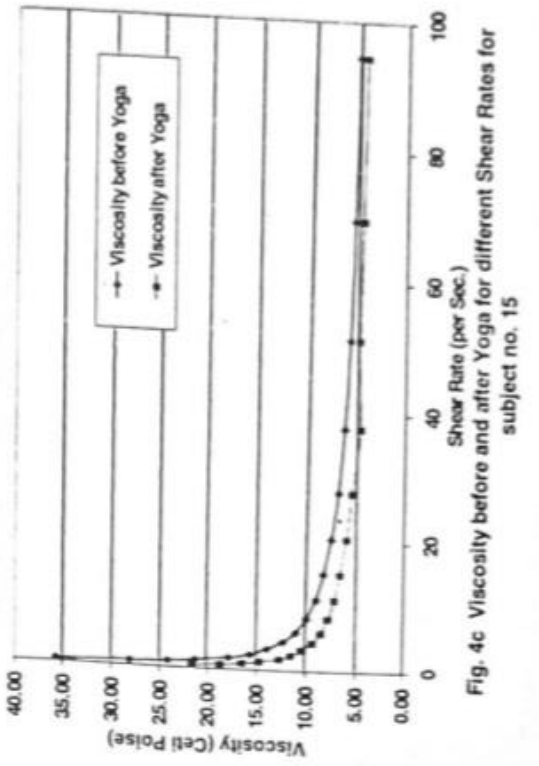

Fig. 4c Viscosity before and after Yoga for different Shear Rates for subject no. 15

Subject no. 16 had some heart problem and had some depression also. She could do only meditation and relaxation practices. After yoga practice aggregability did not reduce much but rigidity decreased.

A feedback talk with subjects 14 and 16 indicated that they were feeling better (relaxed) after these yogic practices. This indicates the possibility of relationship of red cell rigidity with mental tensions and depression. It is interesting to note that Ernst et. al. [6] and Dintenfass and Zadar [7] have made similar observations regarding the connection of mental tension, psychoemotional stress and depression, with red cell rigidity.

CONCLUDING REMARKS

Yogic practices like cleansing processes, Asanas, Pranayam etc. reduce blood viscosity at low shear rate (Table 1 subject no. 3, Table 2 subject nos. 5 and 6 etc.); implying reduction in red cell aggregability. Hence, these Yogic practices may be used to control the aggregability of red cells. Meditation and relaxation part of yogic course appears to be connected with reduction of red cell rigidity. From Table 4 (subject No. 14) and other observations, it appears that these yogic practices (meditation, relaxation etc.) may be used to control the rigidity of red cells.

Over all it appears that with yogic practices the whole blood viscosity drops for most of the subjects over a wide range of shear rates with some variations and exceptions. Those who had health problems and could do yoga practices well, improved significantly.

SUGGESTED FUTURE WORK

Further study can be conducted by increasing sample size and longer and advanced versions of yogic practices. The study can be made more comprehensive by including another group with a different physical exercise program. This would provide insights into the specific effects of yoga compared to other forms of exercise.

Also, the future study could include questionnaire based survey of each subject, before and after the yoga course, and this score can be used to determine their satisfaction. The score can further be correlated to the change in hemorheological parameters of blood. Also, atleast three blood samples could be collected from each subject, both before and after the yoga course, to ensure that no information is lost due to hemolysis of samples collected.

*****

Brief Profile of the Author:

Dr. Satish Kumar Pathak has done Ph.D in Biomedical Engineering. He has retired from Indian Institute of Technology – Bombay where he taught Descriptive Geometry and Engineering Graphics to undergraduates. He was also associated with Robotics Laboratory.

Statements and Declaration: Author is thankful to Ghantali Mitra Mandal, Thane, for providing facilities to collect samples and to subjects who volunteered blood for this experimental study. This work was published in proceedings of 28th National Conference on Fluid Mechanics and Fluid Power, organized by Punjab Engineering College, Chandigarh. We are indebted to them.

References:

1. Yogendra, S., 1956, Yoga-Physical Education, The Yoga Institute, Santa Cruz, Mumbai, India.
2. Nikam, P.R., 1992, Swasthya Yoga (Part I) - Cleansing Processes, Shri Ambika Yoga Kuteer Prakashan, Thane, Maharashtra, India.
3. Nikam, P.R., 1992, Swasthya Yoga (Part II) - Asanas, Shri Ambika Yoga Kuteer Prakashan, Thane, Maharashtra, India.
4. Chaturani, P., Pathak, S.K. and Saxena-Bhartiya, S., Mathematical Modelling of Yogasana and other Exercises, Int. Conf. on Frontiers in Biomechanics, Supplemented with Yoga concepts, Bangalore, Dec. 12-15, 1999, P. 165.
5. Kuwalayananda, S., 1988, Pranayam, Popular Prakashan, Mumbai**.**
6. Ernst, E., Aumann, M.B. and Matrai, A., Prolonged Psychoemotional Stress Decreases Blood Fluidity, Clin. Hemo. 4, 1984, P. 423.
7. Dintenfass, L. and Zadar, J., Blood Rheology in Patients with Depressive and Schizoid Anxiely, Biorheology, 13, 1976, p.33.
8. Ehrly, A.M., Lanograp, H., Herrier, J. and Salger-Larrenj's K., Influence of Vediofilm Induced Emotional Stress on the Flow Properties of Blood, Clin. Hemo. 1983, p.254.
9. Feuerstein**,** G. and Miller, J., 1971, A Reappraisal of Yoga, Rider and Company, London.
10. Fung, Y.C., 1981, Biomechanics, Mechanical Properties of Living Tissues, Springer-Verlag, New York.
11. Dintenfass, L. 1985, Blood Viscosity, MTP Press.