Headstand Day By Day

The Physics and Practice of Yoga Inversions

by Michael Hutchinson, M.A., F.Inst.P.

In the Hatha Yoga Pradipika (HYP), generally the most helpful of the medieval Hatha texts, inversions are not introduced until Chapter III on mudra, after the student has mastered both asana and pranayama. This simple fact tells us at least two things, firstly, inversions were not considered suitable for beginners and secondly firmness and comfort in working both with the body and with the breath were considered absolute necessities.

However, even given these proficiencies, is it always safe for the student to proceed? An earlier article in Spectrum Autumn 2008 by Dr Ruth Gilmore has raised a question which it is important to look at from a physics perspective. Specifically, since a headstand will cause an increased pressure within the cranium, will this in turn increase the stresses on the walls of the arteries supplying blood to the brain?

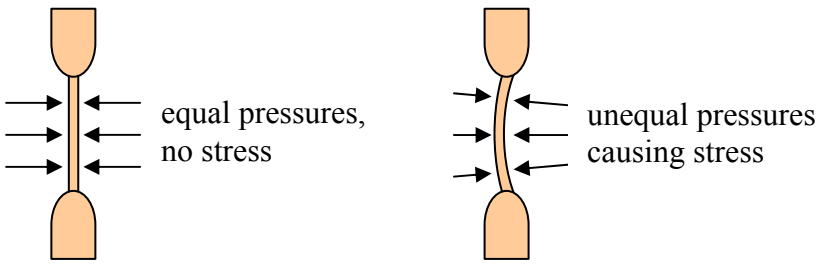
"You are old, Father William," the young man said,
"and your hair has become very white;
And yet you incessantly stand on your head –
Do you think, at your age, it is right?"

"In my youth," Father William replied to his son,
"I feared it might injure the brain;
But, now that I'm perfectly sure I have none,
Why, I do it again and again."

'Lewis Carroll' *Alice in Wonderland: Advice From a Caterpillar*.

To give better advice for less foolhardy persons, we must first understand the nature of *pressure* and *stress*. Pressure is all around us; at sea level the atmosphere exerts the same pressure as would a depth of 10 metres of water. We never feel this pressure because it is the same in all directions and also exists within cells.

However, if we climb rapidly, for example in an aircraft, the lowered atmospheric pressure does not match the pressure of air trapped inside our ears. Because of these unequal pressures, our eardrums experience stress which we feel as discomfort.



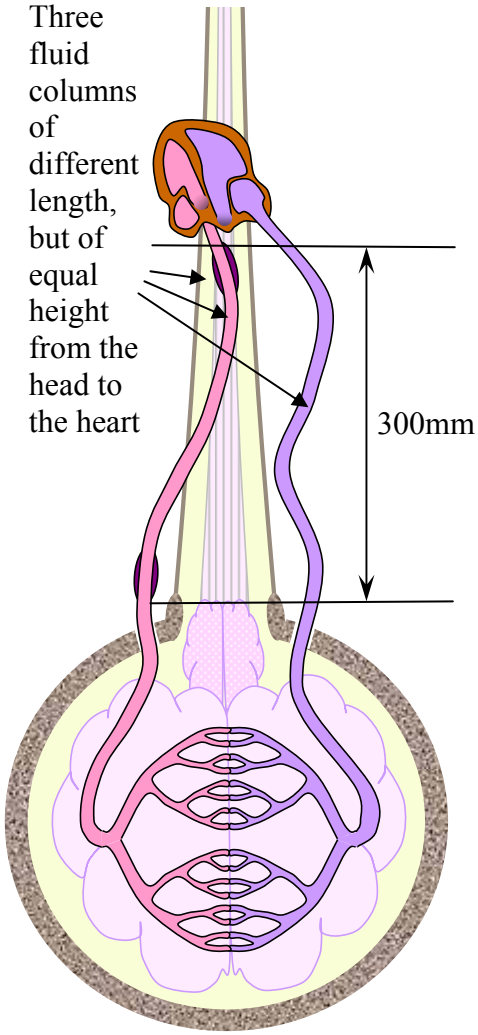
So the question about blood vessels in the brain becomes this: is the additional pressure during a headstand applied evenly or unevenly to the tissues, blood vessels and blood volumes inside the cranium? Let us first consider another situation of increased pressure.

When diving underwater, the situation for the eardrum is reversed. The raised external pressure pushes it inwards compared to atmospheric pressure inside the ear. However, the rest of the body, which does not contain air, simply comes under an evenly applied increased pressure. Even the chest, which contains air, is accustomed to changing its volume, and compresses the air it is holding to match the outside water pressure. All the pressures in all the fluids and tissues the body rise in parallel to the same pressure. This

includes tissues both outside and inside the cranium and, apart from the eardrums, there is no tissue distortion or discomfort[1].

Returning to the headstand, this will place the head the equivalent of about one foot (300mm) of water below the heart. This sets the *amount* of additional pressure, but how will it be exerted? The cranium is effectively a strong box with one large and a few small openings, all of which in a headstand will be uppermost. Running through these openings and up toward the heart and spine are several tubes containing fluids. There are arteries conveying oxygenated blood, veins taking away deoxygenated blood and the spinal column containing cerebrospinal fluid (CSF). The diagram shows the spinal column containing CSF and for simplicity just one vein and one artery leading to and from the heart (in reality there is more than one of each type of blood vessel).

None of these tubes have valves, so the fluid in each one acts like the mercury in a barometer to apply the same pressure, relative to the heart. The carotid arteries apply 300mm of additional water pressure, equivalent to about 20mm of mercury (20mmHg), to the arteries in the brain. The jugular veins do the same to veins inside the cranium and finally the spinal column pressurises both the CSF and the brain which floats within it, again to 20mmHg above atmospheric pressure. All this happens immediately[2] the head is placed below the heart. An artery supplying part of the brain sees both its internal pressure from the blood and the external pressure from the brain tissue rise in parallel. It feels no additional stresses, only the normal fluctuating internal pressures sent to it from the heart and it does not *feel* the additional pressure from the inversion.



The same point is made by Dr Roger Cole in his reply to a question from a student that was sent to the Yoga Journal website in 2004 and he was correctly quoted by Zoe Knott in Spectrum Autumn 2007.

Dr Gilmore also expressed a concern regarding blood flow to the brain. This depends on a healthy positive pressure in the cerebral arteries, relative to a much lower pressure in the veins that drain blood from the brain. This allows the smaller arterioles to contact and dilate to provide each part of the brain which they serve with its exact requirement at each moment.

We have already seen that in moving from standing, to lying or crouching and then to an inverted position that the pressures in all the fluids in the cranium rise and fall in concert. Therefore, given a steady heartbeat, a constant fall in pressure from arteries to veins is maintained and the work of the arterioles to regulate blood supply is unaffected by such a gradual inversion.

Rapid entry into an inversion will, however, require extra effort by the heart to redistribute blood from the lower to the upper body. This will cause a temporary increase in blood pressure. However, this can be avoided, if an inversion is approached gradually. Exit from an inversion should also be gradual, or a lack of blood returning to the heart,

[1] One would need to dive to about 300 meters depth before the water pressure will cause malfunctions.
[2] Actually, it happens at the speed of sound, i.e. in less than 1/1,000th of a second.

caused by sudden drainage into the lower body, may cause a momentary fall in blood pressure to the brain.

Does this mean that inversions are safe for everyone? No, it doesn't. Firstly, we must consider both the abnormal mechanical loads through bone and connective tissue and the unusual demands placed on muscles, throughout much of the upper body. Any history of head or neck injury, any arthritis of the neck or any issues with the upper thoracic area may preclude the taking of significant body weight onto the head. Also, poor upper body posture, often seen as a combination of thoracic kyphosis and cervical lordosis will lead to additional and potentially damaging stresses should inversions be attempted.

Secondly, all the tissues of the head outside the cranium remain at atmospheric pressure. They do not have the CSF, contained within the cranium, to compress them against raised pressure in the blood vessels. Their arteries and veins therefore do feel the extra 20mmHg pressure, which they must contain by bearing additional stress. The face becomes flushed and there may be discomfort in the sinuses as their linings swell. In certain types of glaucoma[3], vision will become blurred or may even be lost. Should disturbance of vision occur, inversions should be avoided and medical advice sought.

Also, considering the high incidence of atherosclerosis (hardening of the arteries) in older people either with diabetes or with high blood pressure (even if controlled by medication), great care is needed. In consultation with Dr Ruth Gilmore, such people are strongly advised NOT to attempt full, sustained inversions, such as headstand or shoulderstand.

Finally, inversions place unusual stresses on the heart. As indicated above, at least one litre of blood, normally held in the abdomen and legs, will drain to the heart. This additional load is transient and is no problem – for a healthy heart. However, anyone with a cardiovascular problem, and anyone over a certain age, should approach inversions with especial slowness and caution.

The above are only the most common and salient medical conditions that may preclude the practice of inversions. Yoga students may have other health issues, diagnosed or undiagnosed, that preclude full inversions. A fuller list, prepared in consultations with Drs Ruth Gilmore and Peter Blackaby, is available from the author on request. Proceeding step by step is always the safest route. In this way the student will be able to consult a teacher or medical practitioner at any point when a problem seems to be arising, and most likely before any harm can be done.

Yet this should not surprise anyone, since a gradual approach is exactly what the HYP advised, centuries ago, even for a young, fit student. Chapter III, verse 81 states:

"*Hold the feet up and the head down for just a moment on the first day. Practice it longer and longer every day.*" (translation by Brian Dana Akers)

The process of training with asana and pranayama will first bring the student into the best state of health possible. Given the wide range of asana-s available to the modern student, thanks to teachers such as T. Krishnamacharya, there are a number of semi-inverted postures in which student can accustom his or her body and breath to at least some of the unusual stresses that the headstand will apply. For example, they place additional weight on the diaphragm, which must learn to function smoothly, despite this abnormal load.

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[3] Glaucoma is a condition where the fluid pressure within the eye is abnormal. Any additional pressure in the eye or the CSF behind the eye may take either the retina or the optic nerve into an overstressed condition. Any loss of vision will probably be temporary, but is the risk worth taking?

Even given this lengthy preparation, Swatmarama (HYP III, 81) is very clear. On the first attempt, the inversion should be held "*just for a moment*". Duration should be increased little by little and "*dine-dine*", literally "day by day". The student, already trained in asana and pranayama, should be able to relax into the headstand, practising every day, holding the position firmly and comfortably (Patañjali, *Yoga Sutra*, II, 46), breathing smoothly and slowly (Patañjali, *Yoga Sutra*, II, 49) and adding one or two more breaths stay each week. However, before embarking such a lengthy but necessary programme to take ourselves or our students safely towards the headstand, we should first consider what the purpose and benefits of such inversions may be.

Helpful and encouraging exchanges with the following contacts are most gratefully acknowledged, Zoe Knott, Ruth Gilmore, my teacher Gill Lloyd and Kim Parker, Emeritus Professor at Imperial College, London.

References:

1. Svātmarāma, *Hatha Yoga Pradīpika*, Chapter III, vs.78-82, (translation by Brian Dana Akers, pub. YogaVidya.com), 15th c.
2. Dr Ruth Gilmore, Horses for Courses: The Benefits and Potential Hazards of Sirsasana (Headstand), *BWY Spectrum*, Autumn 2008, pp.14-15.
3. Dr Roger Cole, High Blood Pressure and Inversions, http://www.yogajournal.com/practice/594 , accessed 4th February 2011.
4. DCT Zoe Knott, Inversions, The Journey Towards Sirsasana, *BWY Spectrum*, Autumn 2007, pp. 18-21.

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