A Critical Review of Instrumentation for Recording Nadi

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ABSTRACT

Nadi is the subjectively felt movement experienced by the fingertips or fingerpads of the three fingers, index, middle and ring, placed at three specific sites near the wrist curled over the radial artery. The perceived movements are characterised by certain attributes of which 'gati' happens to be the most important attribute. Nadi vijnana is the art of feeling nadi and interpreting its attributes in terms of physical, mental and spiritual aspects of life.

Attempts have been made to develop electronic instruments to capture attributes of nadi, principally, the nadi gati. The motivation is to replace the subjectivity associated with the feeling of nadi and its interpretation. A brief review of the instruments is presented. It is argued that the instruments, as of date, merely record the wrist pulse (allopathic pulse) at three sites and that these instruments don't capture the nadi gati or associated attributes in the traditional sense. The author's conjecture is that some of the attributes may arise due to an interaction between certain characteristic subtle vibrations inherently present in the fingerpads and the cyclic pulsatile blood flow through the radial artery. If such a conjecture is true, any attempt to capture nadi gati by replacing fingertip or fingerpad by a sensor is self-defeating.

Keywords: Nadi, Vata, Pitta, Sleshma, Kapha, nadi gati, wrist pulse, pulse diagnosis

1. INTRODUCTION

The ancient Indian civilization has made singular contributions in the areas of Astronomy, Phonetics, Grammar, Mathematics, Medicine (Ayurveda), Yoga etc. Nadi, in the context of Ayurveda, refers to certain characteristic movement felt over the radial artery near the wrist, in a manner very similar to feeling the wrist pulse. Three specific sites on the radial artery are chosen for feeling the nadi. The three sites are referred to as Vata, Pitta and Kapha or Sleshma sites. Index, middle and ring fingers are placed over the Vata, Pitta and Kapha sites, respectively. Nadi vijnana, though considered as a branch of Ayurveda, plays a significant role also in Yoga. Nadi vijnana refers to the art of feeling the nadi and interpreting the associated attributes in terms of physical, mental and spiritual (adhi-bhautika, adhi-daivika and adhyatmika) planes of life.

A well trained physician can make an accurate diagnosis based on *nadi pariksha* (examination) alone without even inquiring a patient about the symptoms. In recent times, nadi vijnana has attracted a wide attention. There are many classical and contemporary books as well as review articles with an emphasis on medical diagnosis. Only a few select references are mentioned here (Lad, 1991, Lad, 2006, Mahesh et al 2008; Dattatraya et al, 2014; Kumar et al, 2017a). References to the original classical works and other secondary sources on nadi can be obtained from these select references.

The scope of nadi vijnana extends beyond medical diagnosis [Sriranga Mahaguru, 1945 and 1988]. According to Sriranga Mahaguru, every input, such as food or sensory, to a human system, produces distinct changes in the attributes

of nadi. This forms the basis for the subject matter of dravya-guna, the basis of Ayurvedic pharmacology. There is an intimate relationship between Ayurveda and Yoga as exemplified in a prayer offering salutations to Patanjali Maharshi wherein he is described as a proponent of Yoga, Ayurveda and Sanskrit Grammar. The term 'Ayu:' in Ayurveda signifies 'prana', a central concept in yoga. The term 'nadi' in the context of Yoga refers to a nervous path along which prana is flowing through at any given moment (Khedikar and Mukund, 2016). According to Sriranga Mahaguru, knowledge of nadi vijnana has been used in the evolution of yoga practices (asanas, pranayamaa, meditation etc) as well as in the shaping of various traditional customs and rituals of the ancient India (sanatana Bharatiya dharma) [Chamu, 1972, Chamu 2012, www.ayvm.in, Ananthapadmanabha, 1999].

There is an element of subjectivity involved in the feeling of nadi and in the interpretation of nadi gati. In order to develop an expertise in this area, a keen tactile skill and long duration practice are required. Trained experts as per tradition are rare to be found. There exists different schools of practice. It is a time consuming process to transfer the subjective traditional knowledge from one generation to the next via personal interaction. In this context, the need for objective instrumentation is well recognized. Inspired by tradition, pulse signal is recorded, at three sites as recognized by tradition, using sensors and associated instrumentation. Automatic classification algorithms are applied on the features extracted from recorded pulse signals for a differential diagnosis. Some parameters extracted from the recorded signal are assumed to represent the traditional attributes of nadi.

An attempt is made in this paper to critically review the available instrumentation for recording nadi from the author's perspective. The paper begins with a very short introduction to the subjective approach being practiced for feeling nadi. Such a background is essential to evaluate the performance of instruments developed for recording nadi. Some available instruments are reviewed. According to the author, a rigorous scientific validation of the instruments vis-a-vis traditional knowledge seems to be lacking. There is no clear answer to a question such as 'under a given experimental situation, do these instruments detect changes that are well correlated to the changes predicted by traditional experts?' The author concludes that the present day instruments merely record the conventional wrist pulse at one or more sites and that the recorded signals don't capture the attributes of nadi as per tradition. An instrument to record nadi gati in the traditional sense is yet to emerge.

2. ABOUT NADI

2.1 The Origin of Wrist Pulse

Human heart pumps blood, in bursts, cyclically throughout the body. Oxygenated (pure) blood is pumped into aorta by the contraction of left ventricle of the heart. The aorta expands (dilates, increases in diameter) to accommodate the extra blood. The diameter at the entrance of aorta returns to its normal value after left ventricle completes its function of pumping of blood. This cyclic expansion and contraction at the entrance of aorta propagates along the arterial wall as a pressure wave (Levick, 1991, p.103; Milner, 1990, Ch. 6). A consequence of this is the repetitive 'pulse' felt on the radial artery near the wrist. This 'wrist pulse' is felt by placing one or more fingers superficially curled over the radial artery just below the wrist. The velocity of propagation of the arterial pulse is in the range of 400 to 1000 cm/sec. Blood itself moves away from the heart along the arteries at a much lower velocity of about 20 cm/sec.

2.2 Pulse and Nadi: Commonalities and Differences

In the contemporary literature, 'nadi' and 'pulse' are used almost interchangeably and 'nadi pariksha' is often translated as 'pulse diagnosis'. We emphasize that the perceived subjective feeling associated with 'nadi gati' and 'pulse' are entirely different. We prefer not to translate nadi as pulse since it would be like translating a proper name.

By feeling 'wrist pulse', an Allopathic medical practitioner infers the number of heart beats per minute and the strength of the pulse (strong or feeble). On the other hand, the subjective feeling associated with nadi is described by attributes that are very distinct from those associated with a pulse. Of the various attributes, gati is the most important attribute that is related to the apparent movement felt under the fingerpad. The relative dominance at the three sites with respect to gati is referred to by the term, dosha. Thus, the terms Vata dosha, Pitta dosha and Kapha dosha are used in practice. Other attributes [Lad 2006] are vega (rate or speed), tala (rhythm), bala (force), akruti (tension/volume), tapamana (heat) and kathinya (stiffness) etc.

Most persons are familiar on how to feel the 'wrist pulse' as in modern Allopathic system. Nadi is felt in a very similar manner. Though, both 'pulse' and 'nadi gati'

are felt by the fingers placed over radial artery, yet the two subjective experiences are distinctly different. How come that one and the same underlying phenomenon gives rise to two different perceptual experiences in the tactile mode?

The differences arising in the two subjective experiences of 'pulse' and 'nadi' can be appreciated by an analogy to the concept of 'figure' and 'ground' in visual perception. Readers may be familiar with a visual experience where one and the same image appears as either two faces in profile or as a vase in the middle. If readers are not familiar with such an image, they can find such images on the web (See 'Rubin Vase'. in Wikipedia). Such a shift in the visual experience occurs because of a shift in 'figure' and 'ground'. In this context, a familiar experience with respect to the relative movement may be recalled. All movements are relative. If A moves with respect to B, we can say that B is moving relative to A. When a person seated in a stationary train at a railway station looks through the window at an adjacent moving train, that person feels as though the train in which he/she is seated itself is moving whereas if the person looks through the opposite window towards the railway station, the person feels no movement. Such a difference in experience can be attributed to a shift of 'ground' or the 'reference'.

2.2.1 Fingertip or Fingerpad to feel Nadi?

In the context of feeling nadi, in the literature, both the terms 'fingertip' and 'fingerpad' have been used. Fingertip refers to the semi-circular fleshy part just below the tip of the nail. Fingerpad is the inner fleshy part covering the topmost (distal) phalynx or phalange. Fingertip is used in the 'simultaneous approach' and fingerpad is used in the 'sequential approach' of feeling nadi (See Sec. II. D. below)..

It has been reported that there is a sophisticated somato-sensory system (Ch.8, Purves et al, 2004) underneath the fingerpad. Experimentally it has been shown that the cutaneous mechanoreceptors in the fingerpad can capture information accurately about the shape of contact object, contact force and the rate of change of shape (Srinivasan and LaMotte, 1987; Goodwin et al, 1995). Such neuro-sensory systems may be playing a big role in the tactile perception of nadi gati.

2.2.2 Feeling the Distinction Between Pulse and Nadi:

Feeling the pulse: Although feeling of a wrist pulse is a very common experience, we elaborate it as a preliminary to appreciate the feeling of nadi. Place the fingerpad of index finger over the Vata-site; That is, what you consider to be the best guess of Vata-site (See Sec. II. C below). Ensure that other fingers are not making contact with the radial artery. Let the radial artery be considered as the 'ground' (background or stationary). Imagine the fingerpad as the 'figure'. That is, mainly focus on the pressure exerted by the pulse on the fingerpad. A repetitive pulse (conventional allopathic wrist pulse) is felt.

On closer introspection, it may be noted that a small lateral movement is felt due to the impact (or force) exerted by the pulse on the finger. There are three sub-intervals within each cycle with respect to the perceived movement: a pause (no movement), abrupt beginning of a movement, abrupt ending of a movement. Three main factors may be associated with respect to the experienced movement: (a) the beginning (denote as B) and the ending (denote as E) spatial locations. The spatial locations may be remembered relative to the mid-point of the fingertip. (b) the direction of movement from B to E and (c) the speed of movement from B to E. There are a few additional factors: The beginning and ending of the pulse may be felt as abrupt or gradual; The force of the impact is yet another factor.

In the case of a wrist pulse (with radial artery as 'ground' or stationary), locations B and E as well as the speed of movement are perceived to be the same from cycle-to-cycle. Since the locations B and E remain the same from cycle to cycle, the direction of movement experienced also remains the same from cycle to cycle. Usually, this direction of movement is lateral, sideways, i.e., perpendicular to the axis of radial artery.

Feeling the Nadi: In order to feel the 'nadi' at Vata-site, let the fingerpad of index finger remain at the same site as used above for feeling the wrist pulse. This is a case of sequential approach (See Sec. II. D. below.)

In order to feel the nadi, consider the fingerpad as the 'ground' or stationary. That is, pay less attention to the fingerpad of index finger. Treat radial artery as the 'figure' or the moving part. Mainly focus on the relative apparent movement of the radial artery within and around the fingerpad (i.e., experience the movement of pulse in the radial artery). With this shift in focus, identify the beginning and ending locations. The beginning location (B) of apparent movement for successive cycles seems to shift spatially within the fingerpad of index finger. Similarly, the ending location of apparent movement for successive cycles seems to shift

spatially within the fingerpad. This is unlike the feeling of pulse described above where the beginning and ending locations remain the same for successive cycles. Since the finger placement has not been changed, the change in experience has arisen only due to a shift in the focus (attention) and the selection of 'ground' or 'reference'.

Such an experiment may be repeated with the middle finger placed over the Pitta site and ring finger placed over the sleshma or Kapha site. Distinction in the nadi movement at the three sites may be noted.

2.3 The Three Sites: Vata, Pitta and Kapha or Sleshma

Nadi is felt over the radial artery at three specific sites called Vata, Pitta and Kapha or Sleshma. Anatomically, it may be noted that the radial artery stretches in the forearm from elbow to wrist [Gray's Anatomy]. The radial artery usually lies about mid-way along the lateral outer-half (thumb side) of the forearm (right-half of right forearm and left-half of left forearm). However, the actual course of radial artery in the forearm may differ from one individual to another. By searching for the location where the pulse is felt maximally, the course of radial artery and the location of the three sites may be found.

Three fingers, index, middle and ring are used to feel the nadi at the three sites. The order of placement of these three fingers is such that the examiner's thumb is towards the thumb of the Subject (or one's own thumb in case of self-examination). Fingers are curled over the radial artery. Vata site is about one finger width below the root of the wrist on the radial artery (radial tubercle). The fingerpad of index finger is used to feel Vata gati. Pitta site is slightly below the lower edge of the index finger. Middle finger is used to feel the Pitta gati. Kapha or Sleshma site is slightly below the lower edge of the middle finger. Ring finger is used to feel the Kapha or Sleshma gati. Finer adjustments in the placement of fingers are made such that strong cyclic pulses are felt at each site. Chinese and Tibetan system also follow a similar approach of feeling nadi at three sites, which are referred to as Cun, Guan and Chi. The author leaves it to the historians to decide on the precedence of the origin of these different systems.

2.4 Simultaneous and Sequential Approaches for Feeling Nadi

Because of the subjective nature in feeling nadi and its interpretation, training is invariably through a personal interaction with a teacher. There are different schools of practice. Despite diverse types of practice, there are some common grounds such as the choice of index, middle and ring fingers, correct order for the placement of these fingers, choice of right hand (or left hand) for a male (or female) Subject; the choice of three sites on the radial artery, the list of attributes associated with nadi etc.

There are two broad approaches [Lad, 2006] for feeling nadi. In the **simultaneous approach** all three fingers (index, middle and ring) make contact with the radial artery. The tightness of the contact varies depending on the so called 'Level' as described below. Here, fingertips play a major role. This is recommended to ascertain subtle qualities of Vata, Pitta and Kapha doshas. In the **sequential approach**, only one finger is used at a time and the finger makes a gentle contact with the radial artery. Here, fingerpad plays a major role. The sequential approach is said to be useful for ascertaining gross qualities of the doshas. In traditional literature nadi gati is compared to the movement of animals like that of snake, leech, frog, swan etc. To feel such characteristic movements or complex patterns of nadi gati only one finger at a time has to be used. The details of only the simultaneous approach are presented below.

Details of simultaneous approach: The author's training is based on sequential approach. Yet, the author attempts to give a description of simultaneous approach [Lad 2006] as understood by him and this is subject to correction. In the simultaneous approach of monitoring the gati, the **point of impact** of pulse (or the throb) felt on the fingertip is noted. If the point of impact of the pulse occurs near the bottom edge of a fingertip of any one of the three fingers, it is referred to as Kapha Spike, denoted by K. As an example, for a given cycle, if the impact is felt near the bottom edge of the index finger placed over the Vata site, it is still considered as a Kapha Spike. If the point of impact is near the mid-line of a fingertip it is referred to as Pitta Spike denoted by P. If the point of impact is near the upper edge of a fingertip it is referred to as Vata Spike, denoted by V.

Sometimes, the point of contact may be felt in-between the bottom edge and the mid-line (or the upper edge and the mid-line) giving rise to an ambiguity. That is, whether the contact is to be considered as a Pitta Spike or Kapha Spike (or Vata Spike). In such cases of ambiguity, the quality of contact is to be considered. A pointed strong contact corresponds to Pitta Spike, Feeble rapidly changing wavy contact (higher spatial frequency

or shorter wavelength) corresponds to Vata Spike. Deep, slowly changing wavy contact (lower spatial frequency or longer wavelength) corresponds to Kapha Strike.

Quantification of the doshas: The following procedure is followed to determine the relative proportion of doshas. Let us say that nadi is felt for one minute. The number of times Vata Spike occurs is counted. Similarly, the number of times Pitta and Kapha Spikes occur are counted. It may be difficult to keep track of the count of the heart rate as well as all the three types of spikes within the same one minute interval. Hence, heart rate, Vata, Pitta and Kapha Spikes may be counted during consecutive one minute or 30 second intervals..

To simplify the above task, today's technology of audio recording can be used. For each cycle, the sound 'V' or 'P' or 'K' may be recorded. This could be done for about one minute. Later the audio recording may be played and the number of spikes of each category as well as the heart rate may be deduced. If the heart rate is rapid, then only one Spike may be monitored at a time.

The **relative** dominance of doshas is quantified by assigning numbers 1 to 4, where 1 represents decreased or depleted dosha and 4 represents excess dosha, 3 represents balanced dosha and 2 represents an intermediate quantity of dosha, i.e., in-between decreased and balanced doshas. Experts can estimate up to a fraction of one-half. Let the heart rate be 72 per minute. If the number of V, P and K Spikes are 24 each (1/3 of 72), then all three doshas are balanced or equal in proportion. Such a balanced proportion is represented by V3P3K3. As another example, if the number of V, P and K Spikes, respectively, are 12 (far less than 1/3 of 72), 22 (closer to 1/3 of 72) and 38 (much greater than 1/3 of 72), then the dosha is denoted as V1P3K4. This represents decreased Vata dosha, balanced Pitta dosha and excess Kapha dosha. A count in the range of 15 to 18 for a heart rate of 72 may be represented by '2'. Lesser the number of Spikes, greater the depletion or decrease in the corresponding dosha. In the above explanation, we have assumed heart rate to be 72. Appropriate changes in the counts have to be made for a different heart rate. It is the proportion of Spikes relative to the heart rate that is to be noted.

Concept of Level: In the simultaneous approach, there is yet another concept called 'Level' [Lad 2006] related to the tightness with which the fingers make a contact with the radial artery. Before counting the Spikes, all three fingers are firmly pressed as if to stop the blood flow through the radial artery (as in the case of measuring the systolic blood pressure). Then, the pressure is released just enough to feel the throbs or the pulses. This is referred to as the deepest level or the seventh level (Level-7). If the pressure on the radial artery is released so that the fingers make a soft or gentle contact then it is referred to as superficial level or Level-1. For the 'Levels' between 1 and 7, the applied pressure has to be in-between those of Level-7 and Level-1. Of course, deciding on the pressure to be applied for intermediate levels is highly subjective. According the author, an objective way of controlling the 'Level' would be to use a mercurial sphygmomanometer and set the pressure just below the systolic pressure for Level-7 and just above the diastolic pressure for Level-1 and proportionately in-between these two pressures for other Levels.

Level-7 is used to measure the intrinsic prakruti (the congenital prakruti) of the doshas and Level-1 is used to measure the vikruti (or the current) status of doshas.

3. A BRIEF CRITICAL REVIEW OF INSTRUMENTATION TO RECORD NADI

3.1 Commercial Products of Indian Origin

There have been many attempts to develop instrumentation to record nadi using various types of sensors. Pressure (piezo and condenser microphone), photoelectric (optical) or displacement (strain gauge) and velocity (ultra-sound) based sensors have been used. In a single channel recorder, the sensor is placed at one site at a time (Vata or Pitta or Sleshma). A three channel instrument can record 'pulse' at all the three sites simultaneously.

Nadi Tarangini, an early attempt made at IIT, Delhi has undergone various revisions. A description of nadi tarangini has been published (Joshi et al, 2007) where it is mentioned that a strain gauge sensor has been used. The latest model is a three channel commercially available device (Nadi Tarangini, 2019). Nadiswara is yet another commercially available single channel product (Nadiswara, 2019). The technical details of these commercially available devices are not available in the open literature. Outwardly, the sensor used in these two commercial instruments resembles 'PulsePen' of DiaTecne Company (a part of Arterial Tonometer). Nadi yantra (Abhinav et. al., 2008) is a 3-channel mechanical setup that avoids manually holding the sensors at the chosen sites thereby providing hands-free recording to ensure stability, repeatability and long-term acquisition facility.

Based on some features or parameters extracted from the recorded pulse signal for known cases of ailment, a knowledge database has also been built for a differential diagnosis in some of these instruments. Further, some of the measured parameters are assigned the names corresponding to some of the attributes of nadi.

Comments on the above instruments: The term 'nadi' has been used in the naming of these commercial products and traditional names associated with the attributes of nadi have been assigned to the measured clinical parameters. A full scientific justification involves a rigorous comparison of the subjective assessment of these attributes of nadi made by traditional experts with the estimates provided by instrumentation for the same Subjects during the same session. The recorded signal (or the raw data) must be made available for researchers in order to independently evaluate these instruments and for the sake of transparency. Such a rigorous scientific evaluation seems necessary.

Secondly, the procedure used for recording based on the above instruments differs from that of the traditional approach. As per the simultaneous approach (Lad, 2006), as already described, all three fingers are initially pressed firmly on the radial artery as if to stop the blood flow through the radial artery. Then the applied force is released to feel the nadi, the degree of release depending on the 'Level'. Immediately after the release of applied pressure, the Spikes are counted. In the instrument based approach, this concept of 'Level' seems to be missing. Facility to trigger the recording at the time of release is also lacking.

A traditional expert compares the present doshas (vikruti) with the intrinsic prakruti of the Subject to arrive at a diagnosis. In the instrument based approach, only the vikruti seems to be measured.

Thirdly, as described earlier, the pulse is assigned to Vata or Pitta or Kapha Spike depending on whether the point of contact is at the upper edge or mid-line or the lower edge of each of the fingertips. This would require totally nine sensors in the instrumentation, three for each fingertip. Sometimes, the V or P or K Spike is decided based on the quality of contact rather than the location of contact, which is purely subjective and difficult to be implemented in an instrument.

Finally, a traditional expert carefully chooses the optimum location of the three sites to feel the nadi based on the individual anatomical differences. However, in some of these instruments, the relative spacing of the sensors is fixed.

3.2 An Example of a Siddha-based System

Mahesh et al, 2008 describe a three sensor system supposedly meant for Siddha based medical diagnosis. In this setup, a peizeo-electric polymer has been used as a sensor.

Comments: The setup has been used to determine the intrinsic *prakruti* of a group of subjects. The intrinsic *prakruti* so determined by the instrument has not been validated against a judgement made by traditional experts. The system makes use of only the amplitude of the recorded pulse and/or the heart rate, both of which are merely the attributes of the modern day allopathic wrist pulse. Thus, the traditional attributes of nadi have not been used in this study.

3.3 Instrumentation inspired by Traditional Chinese Medicine

Traditional Chinese system of medicine (TCM) uses a diagnostics method very similar to that of the traditional Indian system. A recently published book (Zhang, 2018) covers previous works on the recording of pulse followed by signal processing techniques, feature extraction and classification. A recent paper (Wang et al, 2016) may be considered as representative of the latest in instrumentation. This paper presents a very sophisticated design. Here, an array of photoelectric sensors is initially used to identify the optimal sites for each Subject. Pressure sensors are then positioned and firmly held at these optimal sites by mechanical means without manual involvement. Three channel signals are recorded simultaneously using the pressure sensors. The paper concludes that pulse signal recorded at the traditionally identified sites shows consistent wave shape whereas the pulse signal recorded at other sites shows a wide variability from cycle-to-cycle.

Comment These works don't claim to replicate the traditional Chinese knowledge. Only the choice of sites is inspired by tradition. The recorded signals are considered to be bio-medical signals. They explore the utility of recorded pulse signals at the three sites. Further, instead of an expert's interpretation, automatic classification algorithms have been applied on the features extracted from the recorded pulse signal. For example to classify a group of subjects (closed-set) into diabetic or non-diabetic (Wang et al 2018) etc.

3.4 Anatomical and Blood-flow Differences at the Three Sites

Measurements on the velocity of blood flow over the radial artery at three sites near the wrist has been carried out in order to gain a deeper understanding (Kim et al, 2015)]. Some minor differences in the mean velocity of blood flow profile at the three sites have been reported. Also, it is reported that a hard bone is seen just under Guan (Pitta) site.

Comment: It is not clear if these noted differences in blood velocity profiles are adequate enough to explain the observed systematic differences at the three sites as noted by traditional experts.

3.5 Equivalence of Nadi Attributes and Modern Medical Terms

The motivation with this approach is to find a correspondences between the modern Allopathic clinical parameters and the attributes of nadi so that the attributes of nadi may be measured using the available instruments meant for measuring the Allopathic clinical parameters. Although the approach of finding equivalences between the attributes of nadi and modern clinical parameters is worth pursuing, rigorous controlled experiments have to be planned to calibrate and validate such equivalence involving traditional experts

3.5.1 Bio-electrical Modelling of Nadi Gati

Dattatreya et al, 2014 propose a model to explain the origin of variability in nadi gati. In this context they cite previous works on the relation between nadi and certain biological processes at the cellular level. They suggest measurement of three bio-electrical properties as an alternative to subjective feeling of nadi gati at the three sites.

Comment: Such an equivalence has to be validated by an inter-disciplinary approach.

3.5.2 Arterial Stiffness and 'Kathinya'

Kumar et al, 2017b considers one of the attributes of nadi called 'kathinya' to be the equivalent of 'arterial stiffness'. In their reported pilot study, two parameters, viz., stiffness index and reflection index are computed using signals recorded by Nadi Tanrangini and these indices are shown to differ at the three sites. The noted differences in the measured parameter at three sites is used as a justification of the approach.

Comments: Out of a large number of recordings made using Nadi Tarangini only a small subset of the recordings (with clearly identifiable systolic and diastolic peaks) is found to be usable. This usable small subset has been chosen manually. It is not clear if the chosen recordings correspond to that of the same Subject. The measured parameter, claimed to represent the attribute 'kathinya', is not compared against an independent measurement of arterial stiffness using modern day instruments. In other words, calibration is missing. It is said that tradition mentions differences in 'kathinya' at the three sites. The study also reports differences in the measured stiffness index and reflection index at three sites. Perhaps, the modern clinical parameter 'arterial stiffness' may be applicable to the entire arterial tree and may not differ from one location to another along an artery. One could inquire if 'kathinya' can indeed be considered as equivalent of 'arterial stiffness'.

4. CONCLUSION

We have argued that 'pulse' and 'nadi gati' are distinctly different experiences and that we prefer not to translate the term 'nadi' as 'pulse'. We have presented in some detail the so called simultaneous approach to feel nadi gati. Contemporary effort to build instruments for recording nadi gati has been reviewed critically.

An inter-disciplinary approach is required for validation of instrumentation. When an experimental object is held in the palm, certain characteristic changes occur in the nadi gati compared to the nadi gati for an empty palm condition [See page. 185, Sriranga Mahaguru, 1988]. For example, the experimental object could be a piece of gold. Any suitable experimental object may be used. This experimental situation is not related to medical diagnosis and hence may be performed on any number of normal healthy Subjects. Pulse signals may be recorded with an empty palm and with an experimental object in the palm. These recorded signals may be analyzed to find out if there are correlates that change in a manner predicted by an expert feeling the nadi. The author has developed a two channel pulse recording system using electret condenser microphone as a sensor that is mounted on a stand whose position can be adjusted for each individual. Recorded signals with this setup for twelve Subjects didn't show any significant change for two different experimental objects compared with an empty palm condition.

It is argued that the present day instruments record only the arterial pulse, which may still be useful for a differential diagnosis, the recorded signal being considered as yet another bio-medical signal. However,

it is premature to describe recorded pulse signal as nadi or to assign traditional names of the attributes to the measured parameters without a rigorous validation.

According to the author's conjecture, some aspects of nadi gati may be arising due to an *interaction* of subtle vibrations inherently present in the fingerpad and the cyclic pulsatile blood flow through the radial artery. This conjecture is yet to be tested. If this were to be so, any attempt to record nadi by replacing a live fingerpad with an inanimate sensor would be self-defeating.

Several intriguing questions arise concerning nadi gati. Why, as per tradition, nadi is felt at three locations instead of a single location as in wrist pulse? What factors (anatomical, physiological and neuro-physiological) cause significant and noticeable differences in the nadi gati at such three closely spaced sites (within a few cm)? How come the attributes of nadi carry useful information helpful for a medical diagnosis? How come an object held in the palm produces systematic and consistent changes in nadi gati, that too almost immediately? In other words, what is the rationale behind the origin of 'nadi'?

At this point of time, the origin of nadi gati is a deep mystery that is yet to be unravelled. Wealth of information carried by nadi gati is yet to be fully explored. Traditional knowledge has to be collected, preserved and expressed using contemporary technical terms by an inter-disciplinary team. Instruments to record nadi gati, as distinct from pulse, are yet to be developed, calibrated and validated. Dubbing nadi gati as imaginary is an un-warranted criticism. Such a scepticism closes the doors on a great gift bestowed by Nature to monitor one's physical and mental health as well as one's spiritual status.

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