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Review Article

Review on comparability of 'classical' and 'contemporary' research methods in the context of Ayurveda

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ABSTRACT

Recent discussions on Ayurvedic research almost always end up with a note of discontent about its current methodology and demands for radically different versions. Reinforcement of "classical methods (of the glorious past)" is being envisaged as an alternative. If research is systematic enquiry to bring out truth, its core construct applies to formation of knowledge anywhere in the world, any time, may it be ancient or modern. As a part of debating on the necessity of an alternative, this article tries to check the comparability of 'classical method' (as available from Darsanas and Ayurveda) with 'contemporary method' through examining how much the two systems correspond in relation to the basic construct and terminology of research, under nine domains. The domains include most of the cardinal aspects of research process such as philosophical constructs, research paradigm, basic approaches on reasoning, definition and classification of research, research process based on nature of relationship, planning of interventional research, technical terminology, research reporting and research fallacies. More than sixty technical terms related to classical method are selected and explored for their conformity with contemporary language of research. Meaningful agreement was obtained which suggested that the two systems are comparable. Leaving a space for more systematic, methodical and extensive critical comparison, this review concluded on a suggestion that, one who proposes radical changes in research methodology, may consider the comparability of the two systems, and rethink on an extremist demand for a total reconstruction. Instead, the modus operandi of revising Ayurvedic research may emphasise on prioritizing its preferences and practices.

1. Background

In independent India, "research" started to appear in the active discussions in the field of Ayurveda during late 1950's, precisely after the publication of Udupa committee report in 1958 [1]. This new movement initially motivated discussions on need of research in Ayurveda which turned out into two never-meeting ideas: (1) Ayurveda is time-tested; there is no scope for any new research (2) Ayurveda needs to be subjected to the acid test of scientific scrutiny and only what survives can be accepted [2]. The scientific temperament sustained in India under the leadership of Jawaharlal Nehru, found it essential to validate Ayurveda practices through researches on modern grounds [3]. As a result, various councils, institutions and programs were instigated for research in Indian systems of Medicine. Subsequently, the focus of discussion shifted to the issues related to the fidelity of research methods adopted in validating the principles and practices of Ayurveda. Methods of biomedical research were accused to be ready-made to suit the needs of modern medicine not enriching the Ayurvedic understanding or Ayurvedic concepts [4]. Act of verifying and validating a time tested system, which was formed in a different paradigm, using modern tools and parameters was criticised extensively; an alternate research methodology was widely demanded [5]. Such demands were endorsed by WHO by identifying the need of reviving the methods for clinical research in Complementary and Alternative Medicine (CAM) systems like Ayurveda. WHO categorically stated that clinical research aimed at evaluating traditional medicine should incorporate the conventional concepts of research design; yet, priority of research designs may vary [6]. On the other side, many experts tried to coin and define a term Ayurvedic Research Methodology, which was imagined to (1) consider difference

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between Ayurveda and modern medicine, (2) adopt classical methods of Ayurveda in research, (3) design protocols based on basic concepts and (4) follow the approach of personalised medicine [4]. While pondering on such prospects, experts habitually and spontaneously refer to "a classical method" belonging to "a glorious past of the research methodology of Ayurveda" being illustrated through some terms like Darsana, Pramana, Pareeksha, Anumana etc. [4] Mostly such descriptions fabricate an impression that the 'classical method' stands aloof from present methods of research and needs a radically different contemplation to put them into practice. If research is "creative and systematic work undertaken to increase the stock of knowledge, including knowledge of humans, culture and society, and the use of this stock of knowledge to devise new applications" [7] this applies to formation of knowledge anywhere in the world, any time. If so, the problem of radical difference in between ancient (classical) and modern (contemporary) methods becomes debatable. To initiate such a debate, this review tries to explore the comparability of 'classical research' with 'contemporary research' based on some pre-structured domains. The objective of the present attempt is to comprehend on the feasibility of comparison between the systems, which would trace out future prospects on systematic comparative analysis.

2. Method of review

In this review, methods of acquisition of knowledge with their rich terminology described in Sankhyadarsana, Nyayadarsana and Ayurvedic literature are together taken as classical research methodology. Standard editions of such literature are taken as source materials. Constructs and concepts of contemporary biomedical research, available from authentic e-sources, are taken as contemporary research methodology. For facilitating an easy comparative approach, nine domains are considered, such as (1) Philosophical constructs and research paradigm, (2) Basic approaches on reasoning, (3) Definition of research, (4) Classification of research, (5) Research process based on nature of relationship, (6) Interventional research – planning and process, (7) Research implications of technical terminology, (8) Research reporting, (9) Research fallacies.

Initial survey through the literature could devise 60 items in classical methods which seem to be comparable with contemporary constructs. The terms and their definitions were written item wise and corresponding terms/concepts were selected from contemporary sources. Descriptive comparison was based on broad terms and concepts in contemporary research which are posed against comparable items in classical methods. Tabulated comparison was done in a reverse order, by keeping classical terminology as the baseline and then relating them to modern constructs.

3. Domain wise review

3.1. Research paradigm and philosophical constructs

A research paradigm is "the set of common beliefs and agreements shared between scientists about how problems should be understood and addressed" (Thomas Kuhn, 1962). Guba (1990), explained three characteristics for research paradigm – (1) Ontology (2) Epistemology (3) Methodology [8]. *Ontology* in research can be defined as "the science or study of being" [9] and it deals with the nature of reality. In Indian philosophy (*Darsana*), the ontological approaches extended across many mutually contradictory models to explain nature of existence (*Satta*) such as (1) An ever existing causal reality (*Mula-prakriti*) explained in *Sankhya darsana*, (2) Existence (*Satta*) categorised into multiple empirical and assumptive categories (*Padartha*) in *Vaiseshika darsana,* (3) Single absolute principle (*Brahma*) in Vedanta and (4) Absolute emptiness (*Soonya*) in Bauddha tradition [10]. Ayurveda accepts the ontological approach of *Vaiseshika darsana* by accepting the categories explained there in as the causative entities (*Karana-padartha*) in interventions to bring back health (*Dhatusamya*) of human beings [11].

Epistemology can be explained as the study of the criteria by which the researcher classifies what does and does not constitute the knowledge [12]. Sources of knowledge related to research are presently classified under four categories: Intuition, Authoritarian knowledge, Logical knowledge and Empirical knowledge [13]. *Darsanas* (mainly *Sankhya* and *Nyaya*) and Ayurveda enlist these methods, except intuition, such as Empirical knowledge (*Pratyaksha*), inferential conclusion (*Anumana*) and authoritative knowledge (*Aptopadesa*) as primary means of knowledge acquisition (*Pramana*, *Carakasamhita*, *Vimana* 4/3) Even though intuition is not accepted as a separate mean of knowledge in any of the above disciplines, extra-ordinary perception (*Alaukika-pratyaksha*) explained in *Nyayadarsana*, especially perceptive powers attained through Yoga, (*Yogaja-pratyaksha*) is considered as comparable to it [14].

Methodology is the general research strategy that outlines the way in which research is to be undertaken and, among other things, identifies the methods to be used in it [15]. It includes stating the problem/setting an enquiry, putting/generating hypothesis, collecting the evidences, proposing a method of reasoning, interpretation of the information, reaching conclusion and reporting [16]. *Nyayadarsana*, the most famous system in Indian Epistemology enlisted sixteen technical terms (*Shodasa-padartha*) related to the methodology of attaining and verifying knowledge and considered realization of those items as the most authentic way to attain liberation [17]. See Table 1 for comparable aspects of such terms with contemporary methods.

3.2. Basic approaches on research reasoning

The empirical cycle related to research, especially in bio-medical research, starts from observations, advances to generalization of observations to form a hypothesis (the inductive phase), and finally ends up with testing the hypothesis (the deductive phase). Inductive reasoning is derivation of general principles from specific observations, where-as deductive reasoning is the process of reasoning from one or more statements (premises) to reach a logically certain conclusion [18]. The direction of induction is from observations to generalization, whereas deductive reasoning reduces general impressions to specific applications. Caraka (Sutra 1/44), while describing basic materials and methods related to Ayurveda in the introductory chapter of his treatise (*Caraka samhita*), the description of causal categories (*Karana-padartha*) starts from *Samanya* and *Visesha. Samanya*, the generality principle, by itself suggests an inductive process, adopting a method of reaching in generalization from specific observations. On the other side, *Visesha*, the specificity principle, satisfies deductive process by identifying the way through which a thing is different from another. *Vaiseshika darsana*, which indoctrinated the original concept on six categories (*Shad-padartha*), gave more stress on *Visesha*, as its name indicates; hence, believed to emphasise on a deductive approach. *Nyayadarsana*, the philosophical counterpart of *Vaiseshika*, defines the deductive process (*Tarka*) as "method of deducing an unknown reality based on logical application of reasons" (*Nyayasutra 1/1/40*). *Sankhyadarsana*, tried to build up an inductive approach on nature by connoting a single principle encompassing everything, namely primordial matter (*Mula-prakriti*) characterized by three major attributes (*Triguna*) [19]. This inductive approach, not its content, inspired Ayurveda to formulate a single theory, i.e. *Tridosha*

Table 1
Technical terms enlisted in *Nyāya* system and their research implications

Technical terms	Definition/Meaning (Nyayasutra 1/1/3-1/1/19)	Comparable aspects of modern research
Pramana	Means of right knowledge such as *Pratyaksha, Anumana, Upamana* and *Sabda*	Epistemological methods such as Empirical knowledge, Logical knowledge, Authoritarian knowledge and Analogical method
Prameya	Object of right knowledge, about which the enquiry occurs	Research area, research problem, hypothesis
Samsaya	Doubt, a conflicting judgement about an object	Research question
Prayojana	Purpose, a thing which one endeavours to attain or avoid	Aims and objectives
Drishtanta	Familiar instance; example; truths which are agreed upon generally by people with different intellectual capacities	Information available in public domain; previous studies published; review of literature
Sidhanta	Established tenet/theory; of four types: Multi-disciplinary (*Sarvatantra*), Uni-disciplinary (*Pratitantra*), hypothetical proposals (*Abhyupagama*) and contextually referred theories (*Adhikarana*)	Theoretical construct of the research
Avayava	Components (of a statement which reports the inference) such as proposition (*Pratijna*), reason (*hetu*), similar instances (*Udaharana*), application (U*apanaya*) and conclusion (*Nigamana*)	Methodology of research reporting (Table 5)
Tarka	Confutation; deducing an unknown fact (*Avijnatatatwa*) on the basis of different logics or evidences (*Hetus*)	Deductive reasoning; one among the two basic reasoning approaches in research
Nirnaya	Final conclusion by considering different possibilities	Discussion, interpretation and justification of the research output
Vada	Discussion; adoption of one of two opposing ideas	Accepting/rejecting the hypothesis through due considerations on supportive/contrary findings
Jalpa, Vitanda	Wrangling, a form of fraudulent discussion which aims only at gaining victory	Biased research; manipulating the discussion to reach in the desired results
Hetwabhasa	Unreliable reasons (*Hetu*) which are erratic, non-conclusive and contradictory	Research fallacies in the form of errors, bias, fraudulent evidences, faulty reasoning and plagiarism (Table 6)
Chalam	Quibble, proposition by the assumption of an alternative meaning (of terminology)	Misinterpretation of technical terms or key words, mismatching of title, objectives, hypothesis and conclusion
Jati	Futility, offering objections founded on mere similarity or dissimilarity.	
Nigrahasthana	Rebuke due to wrong deduction	Rejection of the thesis as a result of faulty practices

sidhanta, for explaining innumerable functional states of human biology. The formation of basic doctrines in Ayurveda such as Man-nature-analogy (*Loka-purusha-samya*) and law of homogeneity and heterogeneity (*Samanya-visesha sidhanta*) adopted inductive reasoning. It is evident from the term "*Sarvada*" (*always*) used while describing *Samanya-visesha-sidhanta* (*Caraka Sutra* 1/44) and the term "*Yavantah*' *purushe moortimanto bhaava Visesha*" (means, *whatever* attributes are present in human body) while describing *Loka-purusha samya* (*Caraka Sareera* 5/3) One can never make such extensive and all-encompassing statements (containing words like *always*, *whatever attributes*) through deductive approach. Whereas, method of theoretical deduction is seen in formulating the characteristic features of *Tridoshas* by deducing them from three governing principles of the universe (*Visarga-adana-vikshepa*) applying *Samanya-visesha sidhanta* [20].

3.3. Definition of research

Simplest definition of research is "the systematic investigation into and study of materials and sources in order to establish facts and reach new conclusions" [21].*Caraka* defines a tenet (*Sidhanta*) as a product of a systematic process comprising of multiple attempts of examination by many investigators supported by evidences (*Caraka Vimana* 8/37). Research is again defined as "creative and systematic work used to establish or confirm facts, reaffirm the results of previous work, solve new or existing problems, support theorems, or develop new theories [22]. *Anveeksha*, a term connoted by *Nyaya* system to describe its own prime aim, is defined as the re-assessment of facts which are previously established through empirical methods and authentic verses [23]. The evidence basis of inferential research is well established through the definition of *Anumana* as "it is the correlative analysis of phenomenon with its evidence." (Sankhyakarika 5) Establishment of cause-effect relationship between drug and its pharmacological action, which is the prime concern in bio-medical research, is reflected in the definition of the term *Anusandhana* by P V Sharma: "*Anusandhana* is the exploration of cause effect relationship between drugs, their properties and action."

3.4. Classification of research

In this description, three classifications of research considered for comparison are

Quantitative and Qualitative
Basic research and applied research and
Empirical research and conceptual research

Research is classified into Qualitative and Quantitative, based on the nature of data collected. Of them, Qualitative research, mostly adopted in natural and social sciences refers to the meanings, concept definitions, characteristics, metaphors, symbols and description of things and not to the count or measures [24]. The following trends traceable in Ayurvedic textbooks leave back evidences to agree that Qualitative methods were profusely used in formulating and disseminating Ayurvedic material: (1) Seeking narrative opinions from different experts in formulating scientific theories; eg: different colloquia (*Sambhasha*) in *Carakasamhita* (2) Construction of theory through methodical gathering and analysis of data eg: definition of *Sidhanta* (3) Expressing the ideas in a narrative language, eg: describing symptoms in patients own feelings and language (4) Use of analogical methods and symbolic expressions in explaining theories e.g. "inverted tree" image (*oordhwamulam-adhassakham*) to explain structure of human body [25] and (5) Using convincing metaphors for explaining complex theories eg: "like the toxin in toxic organism" (*Vishena-iva-vishakrime*) while explaining definition of *Prakriti* [26]. Quantitative research, which is the systematic empirical investigation of observable phenomena via statistical, mathematical, or computational techniques [27], was applied to minimal extent in Ayurveda, as evidenced form the

available literature. Even then, a quantitative approach was imparted in some typical instances like grading the quality of elimination therapy based on numerical calculation of number of urges and quantity of excreta (A.H. Sutra. 18/29). Regarding the probability concept of mathematics, later applied largely in statistics, Susruta's description on combinations of tastes (*Rasavikalpa*) was considered to be one of the earliest use of concept of permutation and combination in India [28]. Moreover, the *Naiyyayika* approach on concept of probability was extensively studied for their conformity with modern mathematics and statistics [29].

On the basis of purpose, research is classified into Basic research and Applied research. Basic research also called pure research or fundamental research, has the scientific research aim to improve scientific theories for improved understanding or prediction of natural or other phenomena. It is the enquiry about unknown and the process is directed towards the discovery of truth and understanding the nature [30]. Different philosophical schools in India laid down strong foundations of Basic Research, by way of their inquisitive queries on nature of the universe, without being concerned much about their practical utility. Ayurveda also adopted such broad theories to fix itself in a universal perspective and subsequently applied them to derive practically sustainable concepts. In *Susruta samhita*, evolution of universe (*Srishti-prakriya*) is assumed as the basic fundamental doctrine explaining the prime characteristics of a living organism. But, just after this description, he categorically accepts Pancabhuta theory as an applied, practical and precise theory to proceed with all practical applications related to treatment of diseases [31]. With all its limited scope, this instance marks the transition from basic research domain to applied research. Outputs of fundamental enquiries on nature provided some basic constructs adoptable to Ayurveda such as like man-nature mutuality, cause-effect relationship, theory of six categories (*shat-padartha*) etc. which in turn paved way to the construction of applied theories like *Tridosha sidhanta*, *Pancabhuta sidhanta*, *Rasa-pancaka* and many more.

Differentiation between empirical and conceptual research is mainly based on the usage of empirical evidences in establishing a truth. In empirical research the inference will be based on empirical evidences where-as, in conceptual research it will be derived from intellectual contemplations and reasoning [32]. Both are inferential in nature. *Caraka* described inferential process (*Anumana)* in two ways: (1) Inference based on observation (*Pratyaksha-purvam*, Sutra 11/21) (2) Inference derived out of hypothetical arguments based on reasoning (*Yuktyapekshya tarka*, *Vimana* 8/40). Obviously, the first explanation goes along with empirical research and the latter, conceptual research.

3.5. Nature of relationship and causality

Relationship, defined as the correspondence between two variables, is one of the central and most important concerns in epidemiological studies. There are mainly two types of relationships: Correlational (simply, association) and Causal [33]. In *Carakasamhita*, mere co-incidence or incidental relationship (*Yadrichha*) also is taken as a relationship, but not considered as a scientific method (*Caraka Sutra*11/14-15). In ancient methods, there are four grades of relationship such as (1) incidental association (*Yadrichha*) (2) Correlation (*Vyapti*) [34] (3) Causal relationship (*Karya-karana-bandha*) and finally (4) Inseparable (inherent) relationship (*Samavaya, Caraka Sutra* 1/50). Mostly, in bio-medical research, enquiry starts from an incidental relationship between two variables (customarily, an exposure and an outcome); it advances to prove whether they keep a correlation in between them and finally to test whether such a relationship is causal. *Vyapti*, the term comparable to correlation, is the rule of association between two factors. It is in two forms: Positive (*Anvaya*) and Negative (*Vyatireka*). *Anvaya vyapti* is the state of presence of one variable in the presence of the other whereas Vyatireka-vyapti is the absence of one variable in another. Ideal correlation, designated as *Anvaya-vyatireki,* satisfies both the Vyapti's in a relationship (*Tarkasangraha. Anumana.* 12).

In causal relationship (*Karya-karana-bandha*) mostly there is a temporal alignment of the exposure (cause) and outcome (effect), which determines the direction of relationship. *Nyayasutra* (1/1/5-6) explains that if the enquiry is from cause to effect it is called prospective inference (*purvavat—anumana*); if it is from effect to cause it is called retrospective inference (*seshavat-anumana*) and if they are simultaneous it is concurrent inference (*Samanyato-drishta*). *Anumana* and *Yukti*, though similar in process, are considered as separate means in *Caraka Samhita* (Sutra 11/17). *Anumana* describes uni-factorial causality, (single causative factor leading to the phenomenon, eg: seed as a causative factor for upcoming fruit) whereas, *Yukti* tries to consider it as multifactorial (multiple factors leading to a single phenomenon, eg: production of plant from seed, water, well ploughed land and favourable seasons). Among the multiple causative factors described in *Yukti*, some are causes and some others are modifying factors (risk factors in the case of disease causation). This is evident from the example of seed (*beeja*) and plant (*sasya*) where seed is the causative factor and sufficient supply of water (*jala*), well ploughed land (*karshana*) and favourable season (*ritu*) are the modifying factors for forthcoming plant. At the same time, in the formation of fetus all the six factors (*Pancabhuta and atma*) are equally causative (*Caraka, Sutra* 11/23-2).

Table 2 explains how the nature of relationship explained in classical methods reflects in different research designs and other concepts in research process.

3.6. Interventional research – planning and process

Bio-medical research, as a part of scientific method, is different from intuitive process by means of its systematic, pre-designed, structured, repeatable, objective and verifiable sequencing [37]. Generally, pertaining to any efficient plan of action, a pre-structured sequence is said to be pivotal in bringing out desired effects (*karya*) from its causes (*karana*). In *Caraksaṃhita Vimanasthana* (8/67-68), ten components are recommended for thorough consideration for successful realisation of desired effects (*karya-abhinivritti*) of any activity with special reference to successful treatment. If we translate this concept to the context of bio-medical research, it naturally applies to interventional type of research, where an active intervention (such as treatment) leads to the effects. In Table 3 the ten components are evaluated for their research implications, in the context of planning and processing of interventional research. This framework internally assume a logical cause-effect relationship among the components incorporated therein.

3.7. Research implications of technical terminology related to Anumana

Anumana is said to be one of the three primary methods of knowledge acquisition, more related to an internal reflective process (*Paramarsa, Tarkasangrha.* p.88)). It is different from all other sorts of contemplative practices like imagination (*Vikalpa*), hypothetical deduction (*Tarka*), recollection (*Smriti*) etc. in the way that the former bases on immediate and verifiable observations (*Hetus*). The technical terms applied in the context of *Anumana* in *Nyaya* system impregnate some research constructs. Empirical research methods are more identical to methods of *Anumana*, as per the details given in Table 4.

Table 2
Nature of relationship and its implications in research design/process.

	Name of relationship	Nature of relationship	Comparable implications related to Research design/process
No correlation	*Yadriccha*	Incidental relationship, single observation	Case report, single case design in epidemiological research, case studies in qualitative research
	Anubandha	Repeated incidents/observations	Case series in clinical research, series of in-depth interviews or Focus Group Discussions in qualitative research
Types of correlation (Vyapti)	*Anwaya-vyapti*	Positive correlation, Where ever X is there, really Y also is there. Presence of exposure is associated with presence of outcome	(1) In experimental trial its proof is explored in "study group" where exposure (intervention) is expected to deliver outcome (efficacy) (2) In observational study (eg: case control), its proof is explored in "cases" where exposure is expected to develop an outcome (3) In diagnostic test evaluation it represents "true positive" taken for estimating "sensitivity" which measures the proportion of positives that are correctly identified as such [35]
	Vyatireka-vyapti	Negative correlation, Where ever X is absent there really Y also is absent, absence of exposure leads to absence of outcome	(1) In experimental trial its proofis explored in "control group" where there is no intervention, expecting no outcome (2) In observational study (eg: case control), its proof is explored in "controls" where exposure is absent, thus expected to abstain from outcome (3)) In diagnostic test evaluation it represents "true negatives" taken for estimating "specificity" which measures the proportion of negatives that are correctly identified as absent [35]
Types of tools based on correlation (Linga)	*Kevala-anwayee*	A relationship which satisfies positive correlation only	A tool, measure or criteria which is sensitive (true positives out of total observations) but not specific
	Kevala-vyatirekee	A relationship which satisfies negative correlation only (*Tarkasangraha* 5/11-13)	A tool, measure or criteria which is specific (true negatives out of total observations) but not sensitive
	Anwaya- vyatirekee	A relationship which satisfies positive and negative correlations (TS 5/11-13)	A tool, measure or criteria which is both sensitive and specific, to be precise the accuracy of a test
Types of causal inference based on temporality	*Purvavat anumana*	Relationship directed prospectively from cause to effect, from exposure to outcome	Cohort study, which prospectively explore the relationship between a cause (exposure) and a subsequent effect (outcome) [36]
	Seshavat anumana	Relationship directed retrospectively from effect to cause, from outcome to exposure	Case control study, which starts from outcome and look back for its cause [36]
	Samanyato-drishta	Simultaneous cause and effect, concurrent exposure and outcome	Cross sectional study, which studies a relationship between variables of interest at a single point of time [36]
	Yukti	Outcome from multiple causative factors (*bahu-kaarana-yogaja*)	Signifies prediction of outcome through multiple causation; considers involvement of causes and risk factors

3.8. Pancavayava-vakya in relation to research reporting

Reporting the research is an essential stage of the research process and is not just an exercise for our private enjoyment (Miles and Huberrman, 1994) [38]. A research thesis, in form is a lengthy experimental, design or theoretical report, with a problem-method-results-discussion structure [39]. In relation to the process of *Anumana*, research reporting is *Parathanumana*, which reports the investigator's inferences to convince others through a logically sequenced structure with five components (*Pancavayava-vakya*, TS p.106-111). The comparability of the above structure with contemporary research reporting is tabulated in Table 5.

3.9. Hetvabhasa in relation to research fallacies

Fallacy is an error in reasoning, usually based on mistaken assumptions. Researchers are very familiar with the ways they could go wrong due to the fallacies the research process is susceptible to.

Table 3
Karya-abhinivritti-ghatakas v/s Interventional research.

Terminology	Meaning/definition/explanation as per *Caraka Saṃhita*	Research implications
Kaarana	One who performs an activity (*Karta*); Physician in the process of treatment; the initiator	Research investigator or research agency; professionally competent to do research
Karana	The instrument employed in the process of application; such as medicine in the case of treatment	The intervention planned as a part of research; the independent variable
Karyayoni	The condition where the investigator aspire to intervene; such as morbidity (*dhatu-vaishamya*) in the case of treatment	The phenomenon subjected to intervention; defined through assessment criteria; the status defined by pre-intervention assessment
Karya	The (immediate) effect of intervention; such as health (*dhatu-samya*) in the process of treatment	The desired outcome; outcome measures as per proposed *objectives*; the dependent variable; the status defined by post intervention assessment
Karyaphala	Ultimate aim of the intervention; such as attainment of well-being (*Sukha*)	Effect of intervention interpreted on a broader perspective, based on the *aim* of the study
Anubandha	Long term effects of the activity; either positive (*Shubha*) or negative (*ashubha*)	Effects assessed through long term follow up in the form of risks and benefits
Desa	Site of activity in the form of patient (*aturadesa*) and his/her surroundings (*bhudesa*)	Proper selection of participants and study settings
Kala	Time of intervention	Time frame of research
Pravritti	Initiation of activity	Initiation of research based on essentiality and rationale
Upaya	Proper planning and fineness of different components employed in the process	Research planning, selection of proper designs, criteria and quality of intervention

Table 4
Technical terminology of Anumana and their research implications.

Technical term	Definition/meaning	Research implications
Anumana	(1) Method of making knowledge through an internal process based on direct perception (2) Method of reaching in logical conclusions based on contemplative reasoning	(1) Method of establishing the hypothesis through empirical evidences (2) Conceptual deductive approach
Swartha anumana	The investigator reaching in inferential conclusion by himself	The investigator completes the research process and reaches in inference
Pararthanumana	Sharing the inference with others through the application of Panchavayava-vakya	Research reporting, preparation of research thesis (see Table 5)
Sadhya	The fact which the investigator proves through inference	Research output
Paksha	The site where presence of Sadhya is suspected/tested (TS p.103)	"Sample" in bio-medical research
Sapaksha	The site (sample) where the result (Sadhya) is certainly present (TS p.104)	In bio-medical research, "study group" becomes Sapaksha when the hypothesis is accepted
Vipaksha	The site (sample) where the result (Sadhya) is certainly absent (TS p. 105)	"Control group" becomes Vipaksha when the null-hypothesis is rejected
Hetu	The findings/evidences which leads to inference of Sadhya (TS p.95)	Empirical evidences leading to the acceptance of hypothesis and rejection of null-hypothesis
Pakshadharmata	The state where paksha owns the hetu (TS p. 91)	The state where evidences are readily verifiable in the sample, which determines the reliability of the study
Vyapti	The invariable association between Hetu and Sadhya such that wherever Hetu is present Sadhya also will be present there	Correlation (Table 2)
Paramarsa	The knowledge of Pakshadharmata specified by Vyapti	The sample verified for the presence of evidences leading to conclusion
Linga	The observable indicators which lead to the knowledge of hidden facts	Observable/measurable parameters in the form of tools or criteria to assess a phenomenon

Two types of fallacies described in social research ie, ecological fallacy and exceptional fallacy, explain how the reasoning goes wrong when the measurements are affected by generalization and exceptional findings [40]. In classical research, hetu is the evidence/reason cited for proving the result (*Sadhya*). Fallacious *hetus* are called *Hetvabhasa* (Vinodkumar p.171). *Nyayadarsana* enlisted *Hetvabhasa* as one among sixteen technical terms (Table 1), to make awareness on the potential damages that could happen in the presence of such fallacies. There are five types of fallacies, nine including their subtypes. The research implications of each type of fallacy is given in Table 6.

4. Summary of comparison

Regarding the philosophy and paradigm of research, terms like epistemology, ontology and methods were considered to make comparison. The terms as such were found to be directly applicable in both the systems. Ontology was judged to be a major domain in both the systems, though nature of preferences varies. Regarding epistemology, three out four methods such as Empirical knowledge (*Pratyaksha*), inferential conclusion (*Anumana*) and Authentic knowledge (*Aptopadesa*) enlisted in contemporary system, were explicitly available in classical system. Methodology, as described in contemporary system, when perused in the back ground of 16 technical terms described in *Nyayadarsana*, found remarkably comparable in relation to terms like epistemological methods, research area, research question, research hypothesis, aims and objectives, review of literature, final theory, research reporting, methods of reasoning, interpretation & justification, discussion and different types fraudulent practices in research (Table 1).

As an extension to the above index, some more comparable terms such as conceptual deduction, empirical deduction, sample, research output, terms related to study group and control group, correlation, reliability, sensitivity, specificity, accuracy, assessment criteria etc. were identified in the context of *Anumana* (Table 4).

Basic approaches of reasoning, the inductive and deductive approaches, by their very nature, forms two approaches in classical methods also, largely agreed upon by *Sankhya* and *Nyaya-Vaiseshika* systems respectively. In Ayurveda also their depictions could be logically verified. Empirical deduction and conceptual deduction could also be differentially traced for their presence in Ayurvedic literature.

Definitions of research as per different sources were also compared with similar definitions in classical system. Definition of *Sidhanta* by *Caraka*, explanation of *Anweeksha* in *Nyaya* system, concept of *Anumana* in *Sankhyadarsana* and the term *Anusandhana* coined on a later period represent different perspectives through which the term Research is being defined especially in bio-medical parlance.

The review considered three classifications of research for comparison. Among Qualitative and Quantitative approaches Ayurveda is more naturally inclined to qualitative approach, though there are some evidences to justify the quantitative approach sustained in Ayurveda. Based on purpose, fundamental research and applied research equally apply in Ayurveda. Basic research laid down foundations of viewing different phenomena in universal perspective; whereas, applied approach converted such principles to functional theories. Empirical and conceptual methods of research are equally valued in Ayurveda as evident in defining these

Table 5
Pancavayava vakya v/s Research reporting.

Components in Pancavayava-vakya	Definition/meaning (Nyayasutra 1/1/36)	Comparable items in research reporting
Pratijna	A declaration stating the presence of result (Sadhya) where it is tested (Paksha)	Statement of hypothesis[a]
Hetu	Evidences to prove the result	Stating the evidences in the form of findings and observations[b]
Udaharaṇa	Example which is known to possess the property to be established	Previous studies dealing with the similar outcomes or findings
Upanaya	Connective analysis of the findings with examples quoted	Interpretation of data; discussion with previous findings; statistical analysis; testing of hypothesis
Nigamana	Restating the initial statement after justification with evidence	Summarizing the results, accepting the hypothesis

[a] Usually prefaced with the background and essentiality of study.
[b] Stated along with materials and methods to derive findings.

Table 6
Hetvabhasa v/s research fallacies.

Name of *Hetvabhasa*	Definition/Meaning [41]	How it affects research
Sadharana Savyabhicara	*Hetu* present in the absence of Sadhya also	Over extensive criteria taken for justifying a less extensive result; study becomes invalid due to non-specificity of assessment criteria
Asadharana savyabhicara	Evidence (*Hetu*) present in the given sample only, not justifiable in some other sample	Non-repeatability of the evidence; affects reliability of the study
Anupasamharee	The sample (*Paksha*) includes every possible subjects (Sarva)	Almost like a census study, no chance to select a comparative group, affects reliability of the study
Viruddha	Evidence (*Hetu*) indicates the sure absence of Sadhya	Evidences themselves disprove the expected result, affects internal validity of the study
Sat-pratipaksha	The proposed evidence (*Hetu*) is challenged by another Hetu which disproves the result	Among the assessment criteria, one criterion challenges another one which affects the internal validity of the study
Asraya-asiddha	There is no seat (*Asraya*) for the Hetu; ie, Paksha is imaginary	Study actually not conducted, fraudulent research, plagiarism
Swarūpa-asiddha	The evidences (*Hetu*) not actually present in the proposed study sample (Paksha)	Fake evidences, fraudulent research
Bādhita	Evidence (*Hetu*) challenged by another Pramana	Findings in one model (eg: animal model) is challenged by those in another model (eg: clinical trial)

methods almost parallel in the context of *Anumana* in *Caraka Saṃhita*.

Association between variables seems to be crucial in any research event, especially epidemiological research. The review considered terms such as *Yadriccha* (incidental association), *Vyapti* (correlation), *Karya-karanabhava* (causality) to reach in comparison with concept and types of relationship in contemporary research. Ideas related to diagnostic tool validation like sensitivity, specificity and accuracy were found to be logically related with norms of association in classical system. Observational study designs based on exposure-outcome pattern such as cohort, case control and cross sectional are found to be sensefully comparable to three temporal varieties of *Anumana*. Concept of multiple causation and concept of risk/causative factors were identified in relation to *Yukti* explained in *Caraka Samhita* (Table 2).

Research planning, especially related to interventional research, needs a pre-structured systematic approach. A framework with ten factors designated as *Karyabhinivritti-ghatakas*, internally fortified by a reasonable cause-effect relationship, satisfactorily transform the whole process to a sustainable model in evaluating outcomes of an intervention (Table 3). Research reporting structured as problem-method-results-discussion arrangement sensefully matches with the *Pancavayava* structure of *Parartha-Anumana* (Table 5). Research fallacies explained as Hetvabhasa describes various chances of errors and bias met with in research, even more extensively than such descriptions in contemporary system (Table 6).

5. Critical comments

The present review did not consider deep, systematic, item wise comparison, but, tried to derive a gross impression on feasibility of a comparative approach. The intertextuality of terms and concepts seems to be better explored when the comparison is bi-directional. Identification of domains and items for comparison was not done through extensive and exclusive apprehension of the two methods, but, through an impression based identification of terms at random.

An attempt to indicate comparability and overlaps of two systems with heterogeneous theoretical constructs may easily invoke strong criticism especially from those who ardently stand for 'purity' of the science. 'Purity' is always a relative term which cannot exist by itself independent of the premises in which it is discussed. While transdisciplinarity permeates to the practice of medical systems, as it is seen now a days, the theoretical constructs alone cannot stand aloof from such trends. Hence, there is nothing illicit in attempting comparison between systems.

Another side of this issue is reflected in a question, "If two systems are heterogeneous in theoretical construct, is it mandatory that the basic methods in which such constructs are formulated remain radically heterogeneous?" This question addresses the epistemological parameters through which the theories are derived. The finality of this thought settles to another inherent question "did the logical and speculative capacity of man has subjected to that much amount of change, as claimed to be totally different?" Research methodology relies on simple reasoning, by which man derives concepts/theories/constructs either through empirical evidences or through logical conceptual deductions. At different scientific paradigms, devising research processes may differ in its scientific constructs, selection of parameters, preferences in the settings, validity of evidences and employment of criteria/tools/measures. Still, the basic frame of inferential research remains the same as far as the logical thought process of human brains is almost constant. This is evident from the comparisons made so far based on the materials available from two temporally far-off systems. When the above differences are applied to the context of Ayurveda, spontaneously Ayurvedic research falls to a platform equipped by its own theoretical construct, parameters, tools, settings, nature of evidences etc. Naturally, modus operandi of revising Ayurvedic research may emphasise not on reconstructing the basic construct of methodology but in devising new preferences, priorities and practices in synchronization with the theoretical constructs. Simply, Ayurvedic research should prioritize itself in developing tools and parameters reflecting its own theoretical constructs, instead of searching for "another" substantially different methodology which seems to be an "unreal sleeping beauty."

6. Conclusion

This comparative attempt took its form to see the intensity of agreement between classical and contemporary research systems in a circumstance where there is an intensive demand for radical amendments for Ayurvedic research methodology. It considered more than 60 key terms related to classical methods and tried to suggest convincingly comparable ideas in contemporary research. The nine domains selected for the comparison roughly comprise of all important aspects which describe the basic construct of research process such as its philosophy, epistemological identity, methods of reasoning, definitions, nature of association of variables, research designs, research planning etc. Meaningful agreement of basic constructs related to research process put it evident that the two systems are comparable. Hence, one who argues for an alternate research system for Ayurveda, may consider the above comparability, agree on the similitude in prime constructs and rethink on the priorities, parameters and practices rather than keeping an extremist intention for a total reconstruction.

7. Limitations and Recommendations

Limitations are as follows: (1) Efforts were made to make a comparison on random selection of items rather than systematic, exclusive and extensive item devising (2) Dissimilarities and differences between the systems were not considered. Hence, it is recommended for further critical comparative attempts with due focus on disparity and disagreements between the two systems are needed to reach in an unbiased conclusion. Such efforts may consider separate systematic comparative studies on specific aspects with due appraisal on congruence as well as divergence e.g. “Nyaya system vs. clinical research” “Research fallacies vs. *Hetwabhasa*” etc. “Observational designs vs. *Trividha anumana*” etc.

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