



The Physiological Basis Of Tridosha In Regulating Body Kinetics, Metabolism, And Structural Integrity: A Review

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Abstract: According to the *Ayurvedic* system of *Tridosha*, based on the concepts of motion, transformation, and maintaining a stable form, the body can be divided into three components: *Vata*, *Pitta*, and *Kapha*. Though these concepts had a metaphysical dimension in the past, the emerging field of systems biology lends these concepts a scientific expression. This article explores the physiological explanations related to *Tridosha*: *Vata* regulates ion channels, cell movement, and signal flow in cells; *Pitta* regulates enzymatic reactions and energy production in the body through the mitochondria and metabolic functions; *Kapha* regulates the provision of immunity to the body through the maintenance of the extracellular matrix. This article emphasizes that *Tridosha* comprises the essential universal regulatory theme of maintaining the body's homeostasis. It combines traditional explanations of *Tridosha* with the breakthroughs associated with genomics and proteomics research related to the genotypes *Prakriti-CYP2C19-EGLN1*. Merging these insights with the traditional medical understanding will deliver personalized, predictive healthcare programs.

Index Terms - *Tridosha*, *Vata* Kinetics, *Pitta* Metabolism, *Kapha* Structural Integrity, Ayurgenomics, Systems Biology, Homeostasis.

I. INTRODUCTION

The three dynamic forces in *Ayurvedic* medicine, known as *Tridosha*, are *Vata*, *Pitta*, and *Kapha*. These three forces are considered to be the primary regulators of all the vital functions of the body.[1] They are described as dynamic forces that regulate the input and output, metabolism, and storage, and not just some old concepts of body fluids.[2] These three forces, *Doshas*, influence everything from the cells to the entire body. *Vata* is said to be the force behind all large and small movements and communications in the body.[3] It is the regulator of the elimination and nutrient and information flows in the body and is said to be the master of the body's biological clocks. Without *Vata*, the functions of the body would come to a standstill. *Pitta* is said to be the manager of the body's metabolic fire or *Agni*. It is the force of transformation and digestion and is the engine that generates heat and converts raw materials into productive energy.[4] *Kapha* is said to be the force that gives the body its stickiness, lubrication, and form.[5] It is the body's building force that counteracts *Pitta*'s heat and *Vata*'s dispersing actions.

Historically, it was difficult to scientifically prove these concepts because the ancient and modern perspectives are different.[6] Biomedicine tends to focus on individual pathways and may overlook the *Ayurvedic* systems perspective. However, new areas of study such as *Ayurgenomics* and systems biology are now closing this gap. Scientists are now linking the *Doshas* to particular genes, metabolic pathways, and body functions.[7] Recent studies have identified molecular hints for each of the *Doshas*, and it appears that the *Doshas* correspond to ancient, stable control systems within the body.[8] For instance, variations in particular genes for drug metabolizing enzymes and hypoxia-inducible factors according to *Prakriti* suggest that *Tridosha* categories correspond to genetic signatures that determine how the body responds.

Knowledge of the physiological principles of *Tridosha* is essential in developing personalized medical approaches that take into consideration the individual's biological differences.[9] *Prakriti* analysis in *Ayurveda* prevents the concept of a typical patient from arising, unlike conventional medicine. This is due to the *Ayurvedic* system realizing that the symptoms for the same disease will differ from one individual to another based on the individual's prevailing *Dosha*. This literature review explores the influence of the *Tridosha* in controlling movements, metabolism, and the integrity of an individual's body.[10]

Methodology:-

In order to find publications that relate the *Ayurvedic* principles to contemporary physiological knowledge, we undertook a comprehensive literature search. We searched through the major online portals like PubMed, Scopus, Google Scholar, and the AYUSH Research Portal for published research papers from 2000 to 2025. In our search tool, we employed the search terms that relate to the concepts like "*Tridosha* physiology," "*Vata* kinetics," "*Pitta* metabolism," "*Kapha* structure," '*Ayurgenomics*' or '*Systems Biology Ayurveda*.'" In this process of search, we only sought peer-reviewed research publications that discussed the physiological bases for the concepts of '*Vata*,' '*Kapha*,' and '*Pitta*.' Studies that do not have scientific content or that relate only to the philosophies and have not been composed in English were excluded. Among the publications found through this search, we picked the top 35 articles that relate to our objective of summarizing the physiological correlates for the three '*Doshas*.' In this work for reporting our search results and summarizing the findings in terms of the related physiological concepts like kinetics for '*Vata*,' metabolism for '*Pitta*,' and 'structural integrity' for '*Kapha*,' we employed the technique of 'narrative synthesis.' we employed the technique of 'narrative synthesis.

Review of Literature:-

Vata Dosha: The Physiology of Kinetics and Signaling

Vata Dosha, derived from the Sanskrit word *Va* meaning "to move," is the principal motive force in the biological system, regulating all functions involving kinetics and communication.[11] In the hierarchy of *Tridosha*, *Vata* is often referred to as the "king" or *Dosha Raja* because it provides the essential motive for *Pitta* and *Kapha*, which are regarded as "lame" or immobile without it. Speaking from the point of view of modern physiology, *Vata* regulates kinetic principles; signal transduction, cellular transport, and flow of biological fluids.[12]

Ion Channel Dynamics and Neurophysiology: In terms of cellular functions, the operations of *Vata* have been attributed to the action of ion channels and the production of action potentials[13] The nervous system requires the fast and transient flow of ions through the cell membrane for the generation of signals. This flow is the embodiment of biological kinetics. The fast flow of Sodium (Na^+) and outflow of Potassium (K^+) with the nerve impulse corresponds to the 'mobile' (*Chala*) and 'subtle' (*Sukshma*) aspects of *Vata*[14]. The action potential is the embodiment of *Vata*: a wave, an impulse, an excitation, traveling, moving along the axon. To initiate this process, voltage-gated channels must open, allowing ions to move down their electrochemical gradient. This process is transitory, imperceptible, and subject to an instantaneous change, which embodies the hallmark *Ayurvedic* definition of *Vata*. Additionally, the process of active transport, such as the Na^+, K^+ -ATPase pump, used for the maintenance of electrochemical gradients, which drive the action potential, requires the consumption of ATP, which embodies the "cost" or "expense" of *Vata*.[15] It is a pump that acts

against a gradient; it requires a lot of energy to maintain a “potential” for movement. In *Ayurvedic* practices, it is understood that excess *Vata* is a destroyer of energy resources in the body; it has a high expenditure of energy for maintaining ionic homeostasis, which is a hyper-excitability environment.

Intracellular Transport and the Cytoskeleton: In addition to its role in neurophysiology, *Vata*'s relevance is also intrinsic to the cytoskeleton and transport systems of a cell.[16] The inside of a cell is not a stagnant pond but a bustling transport center with molecular transport proteins called kinesin and dynein, which transport molecules through microtubules and, therefore, represent the *Vata* function inside a cell.[17]

Mechanotransduction: The Sense of Touch: Besides, the mechanoreceiving action of the cells, where mechanical stimuli are transduced through the cytoskeleton, shows similarity with the sensory and communicative functions of *Vata*. In addition, the feel of touch, that is *Sparsha*, is ascribed to *Vata*. [19] Biologically, this is mediated through mechanoreceptors responding to physical deformation. At the cellular level, integrins associated with the cytoskeleton orchestrate a tensegrity network, which readily transmits externally applied mechanical forces onto the nucleus instantaneously. This enables the cell to “feel” its surroundings, and it attunes gene expression depending on them—a sort of high-level cellular communication controlled by *Vata*.

Systemic Regulation: On a systemic level, *Vata* governs hemodynamics and the autonomic nervous system, driving heart rate variability and vascular tone.[20] The phenomena of the heart pumping in a rhythmical manner, the movement of the gut via peristalsis, and the expansion and contraction of the lungs are macroscopic manifestations of *Vata*. The ANS, especially the sympathetic branch (fight or flight), typically shows all the characteristics of *Vata*: mobilizing energy, increasing alertness, and routing blood to the muscles—getting ready for movement.

Pitta Dosha: The Physiology of Metabolism and Thermodynamics

Pitta Dosha, which is derived from the root *Tap*, meaning “to heat,” is the “force of conversion” and is essentially “thermodynamic conversion” and/or “metabolism”[21]. *Vata* is movement and *Pitta* is the “engine of conversion” or the “converter.” It fills the gap from “input to output.” Biochemically speaking, *Pitta* is related to the “production of metabolism and the enzymatic conversion of substrates”[22].

Thermodynamics and Entropy: Systems biology models apply the functions of *Pitta* to the turnover of the body by the creation of negative entropy. This is a system that opposes entropy, the measure of disorder. A system at equilibrium will have zero entropy.[23] The system of life relies on the consumption of energy for the constant battle against entropy. It translates the operation of this consumption and processing through *Pitta*. It involves the degradation of complex molecules found in foods into simpler compounds, which entails the release of energy along with the evolution of heat due to body functions.

Mitochondrial Bioenergetics: At a cellular/molecular level, it is linked to mitochondrial energy metabolism and the generation of ATP through the Krebs cycle or oxidative phosphorylation.[24] Mitochondria represent a “fireplace” inside each cell. Reactions involving glucose and fatty acid “combustion” are mediated through enzymes that remove electrons, which move down a potential gradient (electron transport chain) inside the mitochondrial membrane. “Biological burning” is none other than *Agni*. The efficiency of “fire” determines metabolic rate. “Sharp” *Agni* (*Tikshnagni*) indicates efficient “fire” or rapid burning of fuel. “Low” *Agni* (*Mandagni*) indicates inefficient “fires” or slow “burning” of fuel.

Pharmacogenomics and CYP2C19: *Ayurgenomics* studies have discovered marked linkages among *Pitta Prakriti* and genes like CYP2C19 that are involved in metabolism. Cytochrome P450 proteins are extensively utilized by the liver to eliminate xenobiotics (medicines) from the body. They even “convert” molecules into a form that can be easily eliminated by making them water-soluble. Persons with predominant *Pitta* tendencies have the “extensive metabolizer” genotype, thereby facilitating the rapid metabolism of xenobiotics or

endogenous substances[26]. This is a genetic discovery that corroborates the *Tikshnagni* (sharp digestive fire) property of *Pitta* types postulated in *Ayurveda*[27].

Thermoregulation and Inflammation : Moreover, *Pitta* is also associated with body temperature regulation, using techniques such as skin vasodilation or sweating to dissipate metabolic heat—processes that are tightly regulated through autonomic feedback mechanisms.[28] With enhanced production of metabolic heat, *Pitta*'s mechanisms cause blood vessels near the skin to dilate, resulting in the elimination of that heat. *Pitta*'s inherent high levels of pro-inflammatory cytokines such as TNF-alpha again establish a connection between *Pitta* and oxidative stress mechanisms.[29] Inflammation is considered a “hot” process (*calor*) that involves chemical change and destruction of pathogens. However, when *Pitta* becomes enhanced, it causes chronic inflammation, autoimmunity, or tissue damage due to oxidative stress caused by reactive oxygen species.

***Kapha* Dosha: The Physiology of Structural Integrity and Anabolism**

Kapha is seen as the “container” or “substance” of life. In this regard, *Kapha* corresponds to the storage process in system theory.[32] *Pitta* is known to “break down” or be involved in catabolic processes to generate energy. *Kapha*, on the other hand, “builds up” or participates in anabolic processes to store energy. *Kapha* regulates the production of proteins, lipids, and carbohydrates in an organism. The high content of triglycerides and lipids in a *Kapha* person reinforces this aspect of energy storage.[33] In terms of evolutionary theory, *Kapha* corresponds to the “thrifty genotype,” capable of energy storage during times of famine.

Genomic Adaptation: EGLN1 and Hypoxia: Research on the human genome has established the relationship between *Kapha Prakriti* and a particular gene variation in EGLN1, which plays a role in regulating the hypoxia response pathway.[34] The EGLN1 gene is an oxygen sensor. Under hypoxic circumstances, this gene initiates a cascade process, which results in the adjustment of metabolism in order to save energy for the sustenance of life. This gene suggests an adaptation that identifies a definite body function concerning oxygenation and fluid balance, pertaining to “fluid” (*Jala*), as indicated under *Kapha*.[35] This suggests that *Kapha* physiology is naturally primed for endurance and conservation; even with a very limited amount of resources, it can maintain homeostasis.

The Extracellular Matrix and Cell Adhesion: Furthermore, *Kapha* is associated with the biology of CAMs and structural cytoskeletal proteins, which maintain cell shape and tissue integrity.[36] The ECM represents the cement that holds cells together to form tissues. Constituents such as collagen, which provides strength, and glycosaminoglycans, which attract water and hence provide lubrication, represent the biological expression of *Kapha*. The “unctuous” or “oily” (*Snigdha*) property of *Kapha* is expressed as synovial fluid that lubricates joints and the mucous membranes that protect epithelial linings. Disturbances in *Kapha* result in a loss of structure with ensuing fragmentation (e.g., arthritis) or an overexpression of it (e.g., fibrosis).

Immunobiology and Ojas: *Kapha*'s immunobiological attribute is ordinarily referred to as *Ojas*, or the vital essence, which reflects the body's resistance and efficiency in tissue repair mechanisms.[37] *Ojas* is the sublimated essence of all bodily tissues. Biologically, a strong immune system is based on stable energy stores (lipids/proteins) and a well-functioning lymphatic system, both of which depend on *Kapha*. Its “slow” (*Manda*) and “stable” (*Sthira*) properties are expressed in slower metabolic throughput and in the strong tissue growth observed in these types.[38] This stability provides high resistance against disease and decelerates the aging process, provided *Kapha* does not stagnate into obstructions or accumulations (obesity/metabolic syndrome).

Comparative Analysis / Discussion

Systems Biology and the *Tridosha* Model: Integrating *Ayurvedic Tridosha* theory into modern systems biology reveals a highly sophisticated understanding of homeostatic regulation.[39] Whereas modern medicine often conceptualizes physiology through reductionist pathways—isolating the heart from the kidney, or the gene from the environment—the *Tridosha* model adopts a whole-system approach by categorizing functions into input/output, turnover, and storage.[40] This cybernetic view corresponds to the principles of control theory, wherein living organisms maintain stability through complex feedback mechanisms.[41] Control theory argues that for any system to retain stability, it must have a sensor or detector (*Vata*), a controller or regulator (*Pitta*), and a plant or process (*Kapha*) to be controlled. A comparison indicates that *Vata*'s function as a signal transducer corresponds to rapidly acting control processes mediated through the nervous system. *Pitta*'s metabolic activity corresponds to endocrine or enzymatic systems responsible for energy conversion at rates sufficient to fuel the system.[42] The structural activity of *Kapha* corresponds to anabolic drive or body structure, which acts as a shock absorber to buffer sudden system changes.[43]

The Validity of Biochemical Individuality: Interestingly, the *Tridosha* paradigm captures individual variation—often referred to as biochemical individuality—more explicitly than conventional physiological paradigms. In contemporary medicine, drug dosing and diagnostic ranges are frequently based on an “average person” (usually a 70-kg male). Evidence such as differential rates of drug metabolism in *Pitta* versus *Kapha* genotypes argues against this “one-size-fits-all” approach.[44] The *Tridosha* model offers a predictive heuristic for determining “allostatic load,” or the cost of maintaining physiological stability under stress.[45] A *Vata* individual accrues load via nervous system hyperactivity (anxiety, arrhythmia). A *Pitta* individual accrues load via inflammatory overdrive. A *Kapha* individual accrues load via metabolic stagnation and accumulation. Categorizing individuals according to their *Prakriti* provides a predictive tool for disease susceptibility, such as metabolic syndrome in the *Kapha* type.[46] By enabling such prediction, personalized preventive strategies can be applied to counter underlying physiological tendencies before they manifest as overt pathology.

Data Synthesis:

To understand the comparative physiology that will be discussed, the table below summarizes some of the biological correlates for the concept of *Tridosha*.

Physiological Domain	<i>Vata Dosha</i> (Kinetics)	<i>Pitta Dosha</i> (Transformation)	<i>Kapha Dosha</i> (Structure)
Primary Function	Transport, Signaling, Movement	Metabolism, Thermoregulation, Digestion	Storage, Lubrication, Structure
Physical Properties	Dry, Light, Cold, Mobile, Subtle	Hot, Sharp, Light, Liquid, Spreading	Heavy, Slow, Cold, Oily, Stable
Cellular Mechanism	Ion Channels, Action Potentials, Cytoskeletal Transport	Mitochondria, Enzymes, Lysosomes	Anabolism, Extracellular Matrix, Cell Adhesion

Genomic Marker	Signaling Pathway Genes	<i>CYP2C19</i> (Metabolism)	<i>EGLN1</i> (Hypoxia Response)
Systemic Correlate	Nervous System, Circulation	Endocrine System, Digestive System	Skeletal System, Adipose Tissue, Immune System
Dysfunction	Arrhythmia, Neuropathy, Degeneration	Inflammation, Acidosis, Autoimmunity	Obesity, Edema, Congestion

Research Gap & Future Scope:-

Yet despite these encouraging associations, important research gaps continue to persist about standardizing *Tridosha* biomarkers.[47] With regard to SCD, most available literature is based either on genomic associations or simplified phenotyping surveys that currently depend more on indirect biochemical indicators for assessing *Dosha* levels rather than real-time biochemical indicators that would directly measure levels of *Dosha* imbalance.[48] As it stands now, while it is possible to determine a person's *Prakriti* or genetic makeup, we have not pinpointed a method to determine a person's *Vikriti* or current imbalance through standard blood tests. Let us consider a possible ratio of cortisol to insulin levels for a *Vata–Kapha* imbalance.

It is necessary to have strong mathematical tools to model the non-linear behavior of the *Doshas*.[49] Biological systems operate far from being linear, thereby incorporating chaos and complexity. Generating algorithms to model the three-fold interaction of *Vata*, *Pitta*, and *Kapha* would be a revolution in the comprehension of disease pathogenesis.

Future studies will concentrate on multi-omics research, where transcriptomics, proteomics, and metabolomics approaches will be integrated to construct a unified molecular map of *Tridosha*.[50] With a combination of gene expression studies (transcriptomics), protein activity (proteomics), and metabolic byproducts (metabolomics), scientists could generate an “accurate fingerprint” for a *Dosha*. Moreover, clinical trial studies with *Prakriti* classification for patient stratification are required to corroborate the efficacy of personalized *Ayurvedic* treatments for metabolic and degenerative disorders.[51] One of the crucial areas in integrative physiology would be developing accurate, non-invasive methods for ensuring the “status of the *Dosha*.”[52]

Conclusion:The biological principles of *Tridosha* have been established with roots deeply embedded in the most fundamental principles of life, such as motion, change, and stability. Current medical science is now able to verify the existence of *Vata*, *Pitta*, and *Kapha* functions pertaining to motion/signal transmission, metabolism/thermodynamics, and maintenance of integrity/anabolism, respectively. The identification of genomic correlates, for example, the gene *CYP2C19* for the *Pitta* type and the gene *EGLN1* for the *Kapha* type, helps to close the epistemological gap between the ancient knowledge system of *Ayurveda* and contemporary molecular biology. *Tridosha* offers a holistic paradigm that fulfills the need for a systems-oriented model distinct from the reductionist framework of conventional medicine. Identification of these physiological bases will enable conventional medicine to adopt and integrate the principles of *Ayurveda*.

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