

# An Appraisal on Complex Relationship between Vyayama (Physical Activity) and Health: Insights from Ayurveda

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## ABSTRACT

*Ayurveda* has recognized the importance of *Vyayama* (physical activity) at least two thousand years ago. *Ayurveda* mentions the effect of physical activity in maintenance of health while also recognizing its ill-effects when performed inadequately and also excessively. *Ayurveda* has advised that a moderate level of physical activity be incorporated in daily routine to maintain health. *Ayurveda* considers multiple factors while prescribing the physical activity such as *Prakriti* (psychosomatic constitution), age, sex, diet of a person, *Ritu* (season), type and stage of disease, and other concurrent therapeutic procedures. It is point of interest to note that the recent scientific evidences based on physical activity research, too are consistent with the classical descriptions regarding the effects of *Vyayama* on body and mind. Studies have reported that contracting skeletal muscles act as 'endocrine organs' and release myokines and Irisin which perform multiple anti-inflammatory functions, which in turn, reduce the risk of developing various inflammatory and metabolic diseases. *Vyayama* helps in maintaining the balance between three *Dosha* (i.e., *Vata*, *Pitta* and *Kapha*), stimulates *Agni* (~digestive and metabolic strength), enhances *Oja* (~ mental and physical capacity to resist diseases) and helps in maintenance of homeostasis in general. The genetic variations with respect to individual responses to exercise have also been reported which may be relevant in the context of *Prakriti*. The present paper is aimed at discussing and exploring the complex mechanisms of various aspects of *Vyayama* as conceived in *Ayurveda* in view of reported scientific evidences.

**Keywords:** *Vyayama*, *Prakriti*, Adipokines, Myokines, Mitochondrial biogenesis.

## INTRODUCTION

*Ayurveda* is Holistic Indian traditional system of medicine practiced in India since thousands years. The two prime aim of *Ayurveda* are preservation of health of a healthy individual and management of disorders of a diseased person. *Ayurveda* has given great emphasis on preventive measures to remain healthy and to lead a disease free long life. *Ayurveda* scholars have advocated various preventive measures under the instructions of *Dincharya* (daily routine), *Ritucharya* (seasonal regimen) *Sadvritta* (physical and mental code of conducts). *Ayurveda* describes *Vyayama*

under different contexts such as: *Dincharya* <sup>[1]</sup> (daily routine), *Anagatabadhapratisedha* <sup>[2]</sup> (prevention of future diseases), *Balavridhikarabhava* <sup>[3]</sup> (factors enhancing immunity) and also in relation to *Dashavidhaaturapariksha* <sup>[4]</sup> (ten-fold examination of a patient) in the form of *Vyayamashakti* (evaluation of the body strength). In the textbooks, it has been described that *Vyayama* produces feeling of lightness in the body, produces firmness, promotes physical development, luster, and compactness of the body parts, confers the ability to withstand exertion, fatigue, thirst, heat and cold, enhances immunity, causes a

diminution of impurities, reduces the ageing process, and stimulates *Agni* (digestion & metabolism). *Vyayama* is the best form of activity to reduce obesity (corpulence) (S. Ci. 24/39-50).

Recent evidences suggest that regular practice of physical exercise (*Vyayama*) keeps the individual healthy, promotes immunity, maintains psychological wellbeing and protects oneself from various lifestyle- and metabolic disorders such as obesity, cardiovascular disorders, diabetes, back pain, osteoporosis, premature aging etc. [5] Disorders due to lack of exercise (such as childhood obesity and metabolic disorders) are a growing global concern and physical exercise may help in decreasing some of the effects of these problems. According to the World Health Organization, lack of physical activity contributes to approximately 17% of heart diseases and diabetes, 12% of falls in the elderly, and 10% of breast cancer and colon cancer. [6] *Ayurveda* has not only described the beneficial effects of *Vyayama* but also has documented the harmful effects of excessive physical activity and the detrimental effects of *Vyayama* in certain health conditions where it is contraindicated. Exercise is so beneficial for health that it should be considered as a drug. As for any other drug, dosing of physical exercise is very important, otherwise, unfavourable side effects may occur. [7]

This paper, aimed at studying and critically analyzing the mechanisms, physiological bases of the positive effects of physical activity as described in *Ayurveda*, while trying to draw parallels between the two sciences and to discuss if *Ayurveda* can provide newer insights.

## MATERIALS & METHODS

A comprehensive study was undertaken on the descriptions of *Vyayama* found in different *Ayurvedic Samhita*. Descriptions were collected from various *Ayurvedic Samhita* and research papers published in scholarly journals were searched online from scientific electronic

databases viz. PubMed, Google scholar, Science Direct by using the following key phrases: effects of physical activity, stress response to physical activity and severe exercise. Results were analyzed in view of modern physiology to understand the physiological basis of *Vyayama* and its applied aspect as described in *Ayurveda*.

## REVIEW & DISCUSSION

### Historical background:

Historical development of exercise physiology illustrates that interest in exercise and health is not new instead it had roots with the ancients. *Ayurveda* has recognized the importance of *Vyayama* 2000 years ago in maintenance of health and etiology of diseases due to *Ativyayam* (excessive physical activity) or *Avyayama* (lack of physical activity). Marcus Cicero, around 65 BC, stated: "It is exercise alone that supports the spirits, and keeps the mind in vigor. [8] The philosopher Plato (427–347 BC) said: 'Lack of activity destroys the good condition of every human being while movement and methodical physical exercise saves and preserves it. [9]

During the next 2000 years, the field we call exercise physiology has been evolved. Dr. Tripton a well-known contributor in exercise physiology has quoted that *Sushruta* of India was the first recorded physician to prescribe moderate daily exercise along with contribution of Hippocrates of Greece and Galen from Rome who has also recommended use of exercise for management of disease. In 2007, the American College of sports Medicine in association with American Medical Association have termed "Exercise Is Medicine" and launched a global initiative to promote exercise in their practice and activities to prevent, reduce, or treat diseases that impact health and quality of life in humans. [10]

### *Vyayama* (Physical activities)

Physical exercises or activities which produce exertion of the body are known as *Vyayama* (S.Ci.24/38). Physical

activity is defined as any bodily movement produced by skeletal muscles that result in energy expenditure. Physical activity in daily life can be categorized into occupational, sports, household, or other activities. The exercise is a subset of physical activity that is planned, structured, and repetitive and has a final or an intermediate objective the improvement or maintenance of physical fitness. [11]

**Signs of proper Vyayama** - 1. Sweating (*svedaagamah*), 2. Increased respiratory rate (*svashavridhi*), 3. Increased heart rate (pulse rate) (*hridayoparodhaccha*), 4. Feeling of lightness in body (*gatanamlaghavam*), 5. Dryness of mouth (*mukhasosha*), 6. Exertion (*Aayasa*) (C.Su.7/33).

On observation of above described characteristics of *Balardha Vyayama* it seems that scholars of *Ayurveda* have also made the grading of exercise on the basis of energy consumption, cardiovascular and respiratory system responses. The WHO grading of muscular exercise i.e. light, moderate, heavy, severe is made on the basis of Relative load index (RLI i.e. percentage of maximum O<sub>2</sub> utilization), Heart rate. [12]

**Grading of exercise according to Ayurveda** –

The person who is healthy and strong, taking *unctuous* (oily) food should perform the regular exercise of following grade as per the season (A.Hri. Su.2/19,27)

1. Mild exercise (*Alpavyayama*) - in *Grishma*( summer), *Varsha* (rainy).
2. Moderate exercise (*Balardha*) – in *Sharat* (autumn) *Hemant* (dewy), *Shishira* (winter) and *Basanta* (spring) season.
3. Severe exercise (*Ativyayama*)- should not be performed in any season.

Different grade of *Vyayama* is advised in different seasons because the *Sharir bala* (body strength) does not remain same all through the year, it varies with the seasons. *Sharira bala* is *srestha* (best) in *Hemant* (dewy), *Shishira* (winter), *madhyam* (moderate) in *Sharat* (autumn), *Basanta* (spring) and *Alpa* (poor) in

*Grishma*(summer), *Varsha*, (rainy) season (C.Su.6/8).

*Balardha / Ardhashakti* (moderate exercise)- When *Vayu* residing in the region of the heart comes up through the mouth, in other words more upward breathing is the sign of half the strength of the person (C.Su.7/32). Recognizing the various effects of physical activity the American College of Sports Medicine (ACSM) also has given recommendations on the quantity and quality of exercise for adults, and suggested to engage in at least 150 minutes of moderate-intensity exercise each week. A program of regular exercise - beyond activities of daily living - is essential for most adults. [13] Armstrong L. has given guidelines in year 2006 for exercise testing and prescription and defined the exercise intensity as how hard the exertion during exercise. [14] Exercise intensity is measured in metabolic equivalents (MET). Activities with METs between 3.0 to 6.0 have been considered as moderate intensity, where as below 3.0 to 1.5 low intensity, more than 8 as severe category. [15]

**Indications for Vyayama:**

Exercise must be done daily in all seasons. It should be done to the level of half of the strength of the person (*Balardha*). After doing physical activity, the entire body should be massaged mildly. *Vyayama* should be performed after considering the following factors viz. Age (*Vaya*), Strength (*Bala*), Physique (*Shariraprakriti*), Habitat (*Desha*), Season (*Kala*), nature of food (*Ashan*), otherwise person gets affected by disease (S.Ci.24/48). It is indicated in disorders produced due to *Vridhi* (aggravation) of *Kapha dosha* and increased *Meda* like in *Medoroga* (obesity and dyslipidemia), *Prameha*(diabetes).

*Acharya Charak* and *Sushruta* both has advised *Vyayama* in the form of various physical activities like wrestling, sports riding, and brisk walking in prevention and management of Diabetes (a type of *Prameha*) and *Urusthambha* (S.Ci.11/11,C.Ci.6/50). *Sushruta* has advised journey on foot of hundred *yojana*

(one yojana 6 miles approx.) in management of greatly increased diabetes for poor patient (S.Ci.11/12). Now various research studies have shown the evidence that physical activity can increase GLUT4 protein expression and translation by activation of different molecular signalling pathways irrespective of exercise modality and increases the glucose uptake by exercising muscles. AMPK and Ca<sup>+</sup>/calmodulin signalling pathways show a dose response pattern and increase their activity with increasing intensity. [16]

**Exercise should be avoided by the person-**

Ayurveda has advocated some conditions in which physical activity should be avoided by the persons viz. who has just taken meal, is afflicted with thirst (*Trishna*) and *Bhrama* (~dizziness), *Ajirna* (~indigestion), *Raktapitta* (~bleeding disorders), *Krishna* (~emaciation, abnormally thin or weak, especially because of illness or a lack of food), *Sosha* (~consumption) *Svasha* (~dyspnoea), *Kasha* (~cough), *Urahksata*(injury in the chest), *Baala*(child), *Vridha* (old age), individuals of dominant *Vata dosha* constitution, *Krodha* (in state of anger), *Bhaya* (fear), *Shoka* (grief)(S.Ci.24/50,C.Su.7/35)). *Vyayama* causes increase in *Vatadosha* so it not indicated in conditions in which *Vata dosha* is found increased like in old age, weight loss, cachexia and after some *Panchkarma* procedures *Vamankaram*(emesis) (C.Siddhi.2/8,9) [17] *Virachanakarma* (purgation) (C.Siddhi.2/8,9). Physical activity is contraindicated in acute inflammatory state of disease like *Vatarakta*(C.Ci.29/49) (acute stage of gout), *Visarpa*(C.Ci.21/115) (acute fast spreading subcutaneous infection with vesicle formation). Intake of *Madya* (wine) after physical exertion may give rise to different diseases (S.Uttar 47/15). [18] Poisoned person should not perform exercise (S.Kalp6/31). [19] *Sushruta* has advocated that physical activity should not be performed after *Panchakarma* procedures like *Abhyanga* (oleation), *Swedana* (sudation), *Vaman* (emesis), *Virachana*

(*purgation*), enema by decoction or oil (*Vasti*) and *Sirabedha*(S.Sha.8/24) blood-letting by venesection), Suturing of wounds (S.Su.5/38) (*Sevankarma*), management of fracture of bones (*Asthibhagnapratisedha*) (S.Ci.3/4,25)

Recent researches have also identified some medical conditions in which exercise should be advised with precautions or should not be performed. Allyson S. et al, (2007) has given risk factors for heat illness caused by excessive physical activity, that includes dehydration, obesity, concurrent febrile illness, alcohol consumption, extremes of age, sickle cell trait, and supplement use. [20]

**Harmful effect of *Ativyayama*** (excessive physical activity)-*Ayurveda* has not only described the beneficial effects of physical activity but the harmful effects of excessive physical activity have been also mentioned viz. *Trishna* (Thirst), *Aruchi* (Altered taste perception, Nausea), *Charddi*(Vomiting), *Bhrma* (Dizziness), exercise related syncope), *Shirma* (Exertion), *Kasa* (Cough), *Svasha* (Dyspnoea), *Ksata* (Injury in the chest), *Kshaya* (weight loss), *Raktapitta* (bleeding disorders), *Sosha* (Cachexia), *Jvara* (Exercise induced heat injury), *Pratamaksvasha* (exertional dyspnoea in Asthmatics)(S.Ci24/49)

The harmful acute effects of excessive physical activity have been reported by various researchers in sport persons. Excessive exercise leads to dehydration, hyponatremia and exertional heat illness. The early signs and symptoms of dehydration include thirst and general discomfort followed by flushed skin, weariness, cramps, and apathy. At greater water deficits, dizziness, headache, vomiting, nausea, heat sensations on the head or neck, chills, fever, decreased performance, and dyspnea may be present. [21-23] The physical complications of exercise dependence have been documented most comprehensively in long-distance runners. They include repeated soft tissue injuries and stress fractures, pressure-sores, gastro-

intestinal blood loss and anemia, myocardial infarction and death. [24]

**Avyayama (Physical Inactivity) as independent causative factor for diseases:** *Ayurveda* has considered the physical inactivity as etiological factors (*Nidana*) for various disorders like *Prameha* (C.Ni.4/5) *Sthulya* (obesity) (S.Su.15/32), *Medoroga* (dyslipidemia), *Vatarakta* (gout) (S.Ci.5/5), *Krimiroga* (~infectious disorders, worm infestation) (S.Uttar.54/3).

However, the association between physical health and lack of exercise was noticed first time by Jerry Morris in a survey study in 1949 and reported in 1953. Dr. Morris and co-workers noted that men of similar social class with physically demanding occupation bus conductors, mail carriers had markedly lower rates of heart attacks, than more sedentary bus drivers and desk clerks. [25,26] A large no of epidemiological studies have reported a strong, independent direct association of physical inactivity in metabolic and cardiovascular disorders and overall mortality. The contribution of physical activity to health outcomes is independent even when the cardiovascular risk markers and genetic factors are considered. [27-29] U. M. Kujala et.al.(1998) have studied the independent association of physical activity and mortality and the influence of genetic and other familial factors on same sex twins (7,925 men and 7,977 women) and reported that physical activity is associated with lower mortality independent of genetic and other confounding factors. [30]

R. S. Paffen Barger et. al. (1978), in an epidemiological study on 'physical activity as an index of heart attack risk in college alumni' has reported that the risk of first heart attack was found to be related inversely to energy expenditure. Men with index below 2000 kilocalories per week were at 64% higher risk than classmates with higher index. They have also suggested that exercise related health benefits were only evident if physical activity was maintained throughout the life. [31] *Ayurveda* has also advised for regular moderate

physical activity to get the beneficial effects and included it in daily routine.

In a research on myokines, Pedersen and Febbraio (2012) concluded that "physical inactivity and muscle disuse lead to loss of muscle mass and accumulation of visceral adipose tissue and consequently to the activation of a network of inflammatory pathways, which promote development of insulin resistance, atherosclerosis, neurodegeneration and tumour growth and, thereby, promote the development of a cluster of chronic diseases including cardiovascular diseases, T2DM (Type 2 Diabetes Mellitus), cancer and osteoporosis. [32]

**Physiological beneficial effects of Vyayama:** Regular exercise has a lot of scientifically proven health benefits; it has prophylactic and therapeutic values also (Table 1.)

*Sushruta* has advised that physical activity is the best measure to reduce obesity (*Sthaulya*), and the persons who exercise daily are not afflicted by diseases. For mitigation of all the three *Dosha vata, pitta, kapha* *Vyayama* is always best. The role of exercise and physical activity in health and disease has been appreciated by various researchers and now the physiology of exercise has been included as a separate chapter in Modern physiology.

Recognising the beneficial effects of physical activity American College of Sports Medicine (ACSM) has recommended moderate degree physical activity in daily routine and has given guidelines for it. ACSM and the American Heart Association in year 2007, have also reported that routine of daily physical activity (PA) stimulates a number of beneficial physiologic changes in the body and can be highly effective for prevention and treatment of many of our most prevalent and pernicious chronic diseases, including coronary heart disease (CHD), hypertension, heart failure, obesity, depression, and diabetes mellitus. [33]

**Individual variations and their Genetic basis in response to exercise-**

Ayurvedic scholars have described that different constitution (*Prakriti*) individual have different physical strength and tolerance to exercise viz. *Vata* dominant *prakriti*- less body strength and stamina, *Pitta* dominant *prakriti*- moderate body strength and stamina, *Kapha* dominant *prakriti* best body strength and stamina (C.Vi. 8/96-98). Individual variations in response to exercise have been found in various modern research studies and found that everyone not benefits equally from exercise.

A number of studies of both rodents and humans have demonstrated that individual differences in both ability and propensity for exercise (i.e., voluntary exercise) have some genetic basis.<sup>[34,35]</sup> This genetic variation in improvement from training is one of the key physiological differences between elite athletes and the larger population.<sup>[36]</sup>

#### **Vyayama is considered as Immune enhancer (*Balavriddhikara*)-**

*Acharya Charaka* has advised *Karma* (physical activity) as *Balavriddhikara* i.e. immune enhancer. *Shusruta* has said that function of *Oja* is *Sthirupachitamansata* (well nourished compact muscles)(S.Ci24/39-44) and assessment of *Bala* is done by *Vyavyama saktipariksha*. These descriptions indicate that there is certain link between muscle tissue, physical activity and immune mechanism.

The research evidences show that exercise has important modulator effects on immunocyte dynamics and possibly on immune function. These effects are mediated by diverse factors including exercise-induced release of proinflammatory cytokines, classical stress hormones and hemodynamic effects leading to cell redistribution. Biomarkers of inflammation such as C-reactive protein, which are associated with chronic diseases, are reduced in active individuals relative to sedentary individuals, and the positive effects of exercise may be due to its anti-inflammatory effects.<sup>[37]</sup> The neutrophil

concentration increases during and after moderate exercise, where as lymphocyte concentration increases during exercise and fall below pre exercise level after the exercise. NK cell activity increases after moderate exercise.<sup>[38]</sup> The depression in the immune system following acute bouts of exercise may be one of the mechanisms for this anti-inflammatory effect. Stress-induced immunological reactions to exercise have stimulated much research into stress immunology and neuro-immunology. It is suggested that exercise can be employed as a model of temporary immuno-suppression that occurs after severe physical stress.<sup>[39]</sup>

**Vyayam stimulates the *Agni* (*Diptagnitvam*)-** *Vyayama* stimulates the *Agni*, which is responsible for all transformations during digestion and metabolism. Research studies have shown that skeletal muscles quickly adapt to exercise. Muscles from well-trained individuals have more capillaries, mitochondria and improved capacity to store carbohydrates and oxidize fat. N. Psilander (2014) reported that increased mitochondrial function and content within exercising muscles is found to be associated with several of the positive health effects after training.<sup>[40]</sup> Exercise is a very potent stimulator of mitochondrial biogenesis and it does so mainly through PGC-1 $\alpha$ .<sup>[41]</sup> Exercise up-regulates PGC-1 $\alpha$  gene expression and protein activity, as well as the migration of PGC-1 $\alpha$  to the nucleus and mitochondria.<sup>[42]</sup> Russell et al. (2014) hypothesized that the mitochondrial dysfunction and its reduced content are closely related to various chronic diseases and ageing.<sup>[43]</sup> Exercise is a promising treatment for patients with mitochondrial dysfunction. Studies show that prescribing regular exercise is an efficient way to improve cellular and whole body health.<sup>[44]</sup> All these research findings could be taken as evidence to explain the stimulation of *Agni* (Biofire) both at the level of *Jatharagni* (digestive fire) and *Dhatvagni* (fraction of biofire residing in tissues and responsible for tissue metabolism) produced by

*Vyayama*. Mitochondrion is called as powerhouse of the cell as it play great role in dynamic energy homeostasis. Mitochondrial biogenesis which results enhanced mitochondrial function could be correlated with stimulation of *Dhatwagni*. Thus the increased *Dhatwagni* stimulates the *Pachakagni* (digestive fire) since they are dependent on each other and regulate the process of digestion and metabolism.

In *Ayurveda* it is described that *Shariraupchya*(nourishment of body) and *Gatranamsuvibhaktata* (proper muscle growth) is produced by *Vyayama*. In a research on effect of exercise and recovery on muscle protein synthesis in human subjects it was found that although aerobic exercise may stimulate muscle protein break down, this does not result in a significant depletion of muscle mass because muscle protein synthesis is stimulated in recovery. [45]

#### **Vyayama produces tolerance to heat and cold (*Usnasitadinamsahisnutvam*)-**

The scientists have reported that the Irisin hormone produced by muscles during exercise triggers the transformation of white fat cells to cells that behave similar to brown fat cells. [46] The calorie burning effect of brown fat was increased when the subjects were exposed to cold temperatures. [47,48] Findings of these studies are consistent with the effects described under the *Vyayama* that it produces tolerance to heat and cold.

#### **Vyayam reduces obesity (*Sthulyaapkansanam*):**

Ayurveda has described *Avyayama* (physical inactivity) as etiological factor for *Atisthulata*(obesity) and also advised *Vyayama* (physical activity) best remedy to reduce obesity, *Kapha* and *Medavriddhi* (dyslipidemia). Physical activity raises metabolism and helps lose weight more easily. Obesity is characterized by excessive body fat to the extent it causes health problems. Adipose tissue is an active endocrine and paracrine organ that releases a large number of cytokines and bioactive mediators called adipokines that influence

not only body weight homeostasis but also low grade inflammation, coagulation, fibrinolysis, insulin resistance, diabetes, atherosclerosis, and some forms of cancer. Weight loss is associated with a decrease in the serum levels of most of these adipokines, with the exception of adiponectin, which is increased. [49] Peterson A.M. et al (2005) in a study the anti inflammatory effect of exercise have suggested that during exercise contracting skeletal muscles act as endocrine organ and release cytokine IL-6 &IL-8 named it an exercise factor or myokine. [50,51] It is hypothesis of researchers that the adipokines released by adipose tissue which causes low grade inflammation is counteracted by myokines. These findings provide a mechanistic explanation for the protection exercise offers against metabolic diseases and perhaps a network of other chronic human diseases [52,53] and this could be correlated with regulation of *Dhatvagni* i.e. *Mamsaagni* and *Medoagni* which produces proper functioning of *Mansa dhatu* and *Medodhatu*. In *Medadhatuvridhi* the *Medoagni* is found decreased (A.Hri.Su.11/34) so it causes accumulation of *Medodhatu* resulting *Sthaulya*(obesity) and *Prameha*(Diabetes).

#### **Neurobiological effects of Vyayama-**

*Vyayama* produces *Sthairyadukhasahisnuta* (C.Su.7/32) i.e. mental stability and tolerance to various physical and psychological stressors. Some studies have shown that physical activity induces feeling of well being because of increased levels of circulating serotonin and endorphins. [54] Endorphins act as a natural pain reliever and antidepressant in the body. Researchers have suggested that the increased levels of Endorphins and Anandamide are responsible for "runner's high", a euphoric feeling a person receives from intense physical exertion. [55-57] These levels are known to stay elevated even several days after exercise is discontinued, possibly contributing to improvement in mood, increased self-esteem, and weight management. [58]

The Caerphilly Heart Disease Study followed 2,375 male subjects over 30 years and examined the association between regular physical exercise and dementia. The study found that men who exercised regularly had a 59% reduction in dementia when compared to the men who didn't exercise. [59] In mice, exercise improves cognitive functioning via improvement of spatial learning, and enhancement of synaptic plasticity and neurogenesis. [60]

**Delays Ageing (Jaranasha):** Aging is a physiological process influenced by both genetic and environmental factors. People who exercise regularly have markedly lower rates of disability and a mean life expectancy that is 7 years longer than that of their physically inactive contemporaries. [61,62] Research studies have suggested that ageing is associated with increased sympathetic tone, reduced mitochondrial content and its dysfunction. Physical activity reduces the aging process through modulation of sympathetic activity (Seals D. R., et.al. 2000, Grazia D. Femminella et. al, 2013,) [63] and increasing the skeletal muscle mitochondrial content, protein synthesis and its function. [64] Nicholas T. Broskey et.al. 2014 reported in their work that physical fitness is tightly linked to mitochondrial content in a broad and heterogeneous population of older individuals. The anaerobic exercise program, even at an older age, can help ameliorate the loss in skeletal muscle mitochondrial content and may prevent muscle aging co-morbidities such as sarcopenia and insulin resistance. [65]

Practices of regular exercise in older adults have been found effective in delaying the symptoms of cognitive diseases, such as dementia, mood disorders and depression. [66-68] Krik I. Erickson et. al. (2010) have reported in a Study on 120 older adults without dementia that an aerobic exercise performed for one year of moderate-intensity exercise would increase the size of the hippocampus and that change in hippocampus volume would be associated

with increased serum BDNF and improved memory function. [69]

### **Nutritional advises for physically active persons-**

Sushruta has advised that unctuous food and *Abhyanga* (body massage) is always *Pathya* (suitable) for the persons who are performing regular physical activity. Drinking of medicated *Vasaa* (muscle fat) is indicated in weight loss due to exercise (*Vyayamakarshita*) (S.Ci.31/17). *SnehaVasti* (C.Siddhi.4/23) and *Patimarshanasya* (S.Ci.40/51-52) (nasal drops) is also indicated in exertion produced after physical activity and to pacify *Vatadosha* produced after physical activity and to provide nutrition. Kimber et.al, 2003 suggested that proper nutrition is important during exercise in order to aid the body with the recovery process following strenuous exercise. [70] Vitamin C supplementation has been associated with lower incidence of URIs in marathon runners.

Thus it can be summarized that regular practice of *Vyayama* (moderate exercise) results the following effects which help in maintenance of homeostatic state of body and mind -

- Produces balance among *Vata*, *Pitta*, *Kapha* (neuro-endocrinal-immuno modulation)
- Stimulates *Agni* (Mitochondrial biogenesis, regulation of digestive power and metabolism)
- Enhances *Oja* (immunity and mental stability)
- *Srotoshodhan* (clearance of channels and their functional restoration, receptor regulation)

### **CONCLUSION**

*Ayurveda* has given a vivid description related to preventive and therapeutic significance of *Vyayama*. *Ayurveda* has also considered various factors in prescribing the physical activity and its doses like age, sex, physiological state of female, diet, season, nutritional status, disease state, therapeutic procedures etc. Various research evidences has been

found which are consistent with the descriptions regarding effects of Vyayama on body and mind. Research studies have reported that regular practice of physical activities produce neuro-immuno-endocrinological modulations leading to change in metabolism of various tissues which may be correlated with the balancing effect of exercise on *Tridosha Vata, Pitta and Kapha*. Stimulation of *Agni* (Biofire) both at the level of *Jatharagni* (digestive fire) and *Dhatvagni* (fraction of biofire residing in tissues) could be correlated with mitochondrial biogenesis since mitochondria is power house of cell and play a great role in dynamic energy homeostasis, cellular function and its ageing.

Researchers have now suggested that exercise can be used as physical stressor to get its beneficial effect of immunomodulation. *Charaka* has advised *Karma* (Exercise) as *Balavridhikara* i.e. immune enhancer. *Shusruta* has said that function of *Oja* is *Sthirupachitamansata* and assessment of *Bala* is done by *Vyavyama saktipariksa*. These descriptions indicate that there is certain link between muscle tissue, physical activity and immune mechanism, it has been also reported by various recent studies, and further studies could be done on this hypothesis on scientific parameters. Individual variations in response to exercise have been found in various modern research studies. These genetic variations in response to exercise could be studied in relation to prakriti and inferences can be drawn about the stamina and immunity of an individual.

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