



Ayurveda Explorations on Consequences of Excessive physical activity (Ativayayama) and Dose of Physical activity

Vandana Verma*

Kriya Sharia, Faculty of Ayurveda, IMS, BHU, Varanasi, India

Article History:

Received on: 09.07.2019

Revised on: 06.10.2019

Accepted on: 17.10.2019

Keywords:

Excessive physical activity,
Dose of Physical activity,
Ativayayama,
Prakriti

ABSTRACT

Despite the well-established evidence of health benefits of moderate dose physical activity, there are evolving evidences which suggest that a high dose of long duration excessive physical activity may be associated with adverse health effects like dehydration, hyponatremia, exertional heat illness, musculoskeletal trauma, immune and hormonal deregulation, metabolic derangements, CV stress disorders, etc. However, ancient scholars of Ayurveda have well documented the harmful biological effects of excessive exercise (Ativayayama) and considered it under the category of etiological factors of several disorders. Various clinical conditions have been mentioned in which exercise is contraindicated or should be avoided. The harmful effect of excessive physical activity (Ativayayama) described by Ayurveda scholars are thirst (Trishna), altered taste perception, nausea (Aruchi), vomiting (Charddi), dizziness, exercise-related syncope (Bhrma), exertion (Shrma), cough (Kasa), dyspnea (Svasha), injury in the chest (Ksata), weight loss (Kshaya), bleeding disorders (Raktapitta), cachexia (Sosha), exercise-induced heat injury, fever (Jvara), exertional dyspnea in asthmatics (Pratamak svasha). Ayurveda scholars have described Physical activity (Vyayama) in Daily routine (Dincharya), and advocated to performed daily in moderate-intensity only, to get the beneficial effects while the severe grade of exercise is contraindicated. It should be performed after considering the age, diet, season, psychosomatic constitution, psychological state, physiological state of females, disease state, treatment procedures, etc. There are very few recent scientific studies on type and dose of exercise in view of the above-mentioned factors by Ayurveda scholars as per the health state or particular type of disorders and its stage. So it is highly needed to appreciate the perspective of Ayurveda scholars in research, which will be helpful in exploration of a dose of physical activity in the form of mild, moderate and severe grade and its overall effect on health to ascertain that how much activity is needed to get the optimal health benefits.



*Corresponding Author

Name: Vandana Verma

Phone: 9415447692

Email: vandana.verma04@gmail.com

ISSN: 0975-7538

DOI: <https://doi.org/10.26452/ijrps.v11i1.1840>

Production and Hosted by

Pharmascope.org

© 2020 | All rights reserved.

INTRODUCTION

A large no of scientific evidence has established that physical activity generates a series of biological changes which produce beneficial or harmful effects as per the dose of physical activity related to every system of the body. The practice of moderate dose of physical activity not only leads to health and fitness but also can be helpful in the prevention and management of obesity, chronic diseases, including diabetes mellitus, hypertension, coronary heart disease (CHD) and depression, etc. (Haskell *et al.*, 2007).

The evidences suggest that in selected cases, exercise therapy is equally effective as medicinal treatment and in certain conditions more effective than medicines. But there are very few studies on type and dose of exercise as per the stage and particular type of disorders. Ayurveda advocated physical activity (Vyayama) in Daily routine (Dincharya), and suggested that it should be performed daily in moderate-intensity only to get the beneficial effects; after considering the age, diet, season, psychosomatic constitution, psychological state, physiological state of females, disease state, treatment procedure, etc. Ayurveda has mentioned certain disorders and procedures in which exercise is contraindicated or should be avoided viz. after panchkarma procedures like emesis (Vamankaram) (C.Si.2/8,9), purgation (Virachanakarma) (C.Si.2/20,21), internal administration of fat or oil (Snehapana) S.Ni 11/8, fever of recent onset (Tarun Jvara), relieved from fever (Jvaramukta) (S.Utta. 39/157,160), acute stage of gout (Vatarakta) (C.Ci. 29/49, S.Ni.1/40, C.Ci. 21/115) acute fast-spreading subcutaneous infection with vesicle formation (Visarpa) and abdominal distension due to hepatosplenomegaly with ascites (Udara roga), indigestion (Ajeerna), internal administration of fat or oil (Snehapana) (S.Ni 11/8).

Ayurveda has also considered excessive exercise (Ativyayama) among the etiological factors in various disorders. The harmful effect of excessive physical activity (Ativyayama) are thirst (Trishna), altered taste perception, nausea (Aruchi), vomiting (Charddi), dizziness, exercise-related syncope (Bhrma), exertion (Shrma), cough (Kasa), dyspnea (Svasha), injury in the chest (Ksata), kshaya (weight loss), bleeding disorders (Raktapitta), cachexia (Sosha), exercise-induced heat injury, fever (Jvara), exertional dyspnea in asthmatics (Pratamak svasha)etc (S.Ci. 24/49).

Few recent researchers have also reported the harmful effects of excessive physical activity in sports persons presenting in the form of dehydration, hyponatremia, exertional heat illness, immune-suppression responsible for producing various harmful effects , viz. musculoskeletal trauma, immune and hormonal deregulation , metabolic derangements, CV stress disorders etc (Feldman *et al.*, 2015).

Thus the Ancient Ayurveda scholars have observed all the dimensions of Physical activity along with excessive Physical activity. The aim of writing this manuscript is to compile and present the observations of Ancient Ayurveda scholars on Physical activity along with excessive Physical activity before

the health professionals and integrate the pathophysiological basis of excessive physical activity (Ativyayama) and its applied aspect described in Ayurveda or in contemporary literature.

MATERIALS AND METHODS

A comprehensive literature search on descriptions of Physical exercise (Vyayama) and Excessive physical activity (Ativyayama) was done in Different Ayurvedic Samhita and related online scientific research papers and articles. Recent research papers in journals related to it were searched online from scientific electronic databases viz. PubMed, Google Scholar, Science Direct by using keywords, effects of excessive physical activity, the stress response to physical activity, severe exercise. Results were observed and discussed in view of scientific evidences to understand the basis of descriptions on Ativyayama, contraindications to Vyayama in Ayurveda. Table 1 shows, Harmful effect of severe exercise (Smith, 2000; Coverley and Veale, 1987), Harmful effect of Ativyayama (Thakrar, 2017) (S.Ci24/49)

RESULTS AND DISCUSSION

Emerging research data show that physical activity is one of the cornerstones of therapeutic lifestyle changes for maintaining optimal health, longevity, and well being. Now physicians are increasingly prescribing regular exercise for their patients, and WHO has also recommended for inclusion of certain levels of physical activity involving skeletal muscles in daily routine for the prevention of metabolic and chronic disorders. Regular practice of physical activity produces beneficial biological changes that are highly effective for the prevention and treatment of many of insidious, chronic diseases, including cardiovascular disorders, obesity, depression, and diabetes mellitus (Schnohr *et al.*, 2015).

Although the studies suggest that moderate level of physical activity is good for health, but there are evolving evidences which advocate that a high-intensity long-duration excessive exercise may be associated with adverse health effects viz. dehydration, hyponatremia, exertional heat illness, musculoskeletal trauma, immune and hormonal deregulation, metabolic derangements, CV stress disorders, etc.

Ayurveda literature review showed that ancient scholars have given a comprehensive description about the adverse effects of excessive exercise and have mentioned the clinical conditions in which exercise should be avoided or contraindicated.

Table 1: Depicting the Harmful effect of severe exercise (Ativyayama) as described in Ayurveda and similar effects reported in contemporary sciences

Harmful effect of Ativyayama	Harmful effect of severe exercise
Trishna	Thirst
Aruchi	Altered taste perception, Nausea
Charddi	Vomiting
Bhrma	Dizziness, Post-exertional orthostatic hypotension, exercise-related syncope
Shrma	Exertion
Kasa	Cough
Svasha	Dyspnoea
Ksata	Injury in the chest
Kshaya	weight loss
Raktapitta	bleeding disorders
Sosha	Cachexia
Jvara	Exercise-induced heat injury
Pratamak svasha	exertional dyspnoea in Asthmatics

Conditions in which Physical activity should be avoided

Ayurveda has advocated some conditions in which physical activity should be avoided by the persons viz.

1. Child (Bala), old age (Vridha),
2. Dominant Vata dosha person,
3. In-state of anger (Krodha), fear (Bhaya), grief (Shoka),
4. Afflicted with thirst (Trishna) and dizziness (Bhrama), indigestion (Ajirna) (S.Ci.24/50)
5. Emaciation, abnormally thin or weak, especially because of illness or a lack of food (Krisha) (S.Ci. 24/50)
6. Intake of wine (Madya) after physical exertion may give rise to different diseases (S. Uttr. 47/15).
7. Physical exercise just after taking a meal, indigestion (Ajeerna) (S.Ni 11/8)
8. Vyayama should be avoided just after conception (S.Sha.3/13, A.Hri.Su.15/47)

Diseases in which Physical activity should not be performed/contraindicated

1. Bleeding disorders (Raktapitta), consumption (Sosha), dyspnoea (Svasha), cough (Kasha), injury in the chest (Urahksata), (S.Ci.24/50, C.Su.7/).

2. Vyayama causes an increase in Vata dosha, 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 like emesis (Vamankaram)(C.Si.2/8,9), purgation (Virachanakarma) (C.Si.2/20,21).

3. Fever of recent onset (Tarun Jvara), relieved from fever (Jvaramukta) (S. Utta. 39/157,160).

4. A poisoned person should not perform an exercise (S. Kalp. 6/31).

5. Physical activity is contraindicated in acute inflammatory state of disease like an acute stage of gout (Vatarakta) (C.Ci. 29/49, S.Ni.1/40),

6. Acute fast-spreading subcutaneous infection with vesicle formation (Visarpa) and abdominal distension due to hepato-splenomegaly with ascites (Udara roga) (C.Ci. 21/115).

7. Internal administration of fat or oil (Snehapana), causes Kustha roga (skin disorders) (S.Ni 11/8).

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

Excessive physical activity (Ativyayama) as an etiological factor for disorders, Ayurveda scholars have mentioned some disorders in which physical activity or excessive physical activity has been considered as etiological factor viz. Nasal

catarrh (Vatika peenas) (C.Ci.26/143), Dysuria (Mutrakriccha), heart diseases (Hridaroga) (C.Ci.26/32, 76), Piles (Vatika and Pttaja Arsha) (C.Ci.14/13,15), abdominal distension (Vataja Gulma) (C.Ci 5/21), ShakhaAashrita Kamala (Jaundice) (C.Ci 16/125), Hiccup(Hikkka), Dyspnoea (Shvasa) (C.Ci.17/34), Vomitting (Chardi) (C.Ci.20/7)), Gout(Vatarakta) (S.Ni.1/40)), Varicosity of vein (Sira granthi) ((S.Ni.11/8), internal abscess(Antarvridhi) ((S.Ni.9/16), Facial paralysis (Ardita)(A.Hri. Ni.16/19).

Therapeutic procedures

Physical activity should be avoided after Pan-chakarma procedures (five therapeutic procedures for the purification of body), and Shas-trakarma(Surgical procedures).

Purifactory Therapeutic procedures (Pan-chakarma)

oleation (Snehan), foementation (Swedana), emesis (Vaman), purgation (Vrechana), enema (Vasti), venesection (Sirabedha) (S.Sha8/24 Siravyadhavidhiadhyaya).

Surgical procedures (Shastrakarma)

Sushruta has advised in the management of wound that physical activity, long walking(adhva), too much standing, or sitting should be avoided after surgical procedures (Shastrakarma), suturing (Sevankarma) until the wound has attained firmness S.Su. 5/39,19/20,21, 16/ 16, Shastrakarma A. Hri. Su. 29/78, Bhagnachikitsa (management of fractures) Su.Ci3/4,25.

Diseases in which surgical intervention is required

Scrotal enlargement(Vriddhi), Antavridhhi(scrotal enlargement due to intestinal herniation) (S. Chi. 19/3), Cataract(Linganasha) S.Uttar. 17/81).

Physical activity has been also considered as an etiological factor of Hridya roga (ischemic disorders of the heart) (C.Ci.26/77). Several epidemiologic and observational studies have reported a statistically significant association between chronic high-intensity exercise training and elevated risk of AF, cardiac dilatation, cardiac dysfunction, and release of troponin and brain natriuretic peptide (Lavie *et al.*, 2015; Mandsager *et al.*, 2018). Hypertrophic cardiomyopathy (HCM) is a contraindication to strenuous exercise, but low-intensity exercise may be safely accomplished under proper medical supervision.

Pedersen and Saltin (2006) reviewed the possible contraindications of exercise in most of the diseases in which exercise have shown beneficial effects. For

example in patients with CHD, exercise is contraindicated until the condition has been stable for at least 5 days; fever, dyspnoea at rest, acute exacerbations of asthma, aortic stenosis, pericarditis, myocarditis, endocarditis, and severe hypertension, arthritis with acute joint inflammation, uncontrolled diabetes(blood glucose is >17 mmol/L or <7mmol/L), autonomic neuropathy all are contraindications to exercise. Patients with coronary heart disease should refrain from exhaustive exercise. However, in patients with asthma and cases of infection, a pause in exercise is recommended when an acute exacerbation occurs.

In musculoskeletal disorders in cases of acute joint inflammation state like osteoarthritis and rheumatoid arthritis, exercise is contraindicated. High-intensity training or training involving Valsalva-like maneuver should be avoided in patients with hypertension and active proliferative retinopathy. The patients with autonomic neuropathy should maintain adequate hydration and should be instructed to avoid exercise in cold/warm temperatures (Pedersen and Saltin, 2006; Vina *et al.*, 2012).

Few researchers have reported the harmful effects of excessive physical activity in sports persons presenting in the form of dehydration, hyponatremia, exertional heat illness, immune-suppression responsible for producing various harmful effects. Heat exhaustion typically presents with dizziness, malaise, nausea, and vomiting, or excessive fatigue with accompanying mild temperature elevations.

The harmful acute effects of excessive physical activity have been reported by various researchers. Excessive exercise produces dehydration associated hypovolemia and hyper tonicity, which disturbs the physiological functions, altered thermoregulatory, and cardiovascular response further increases the risk of developing exertional heat illness. (Casa *et al.*, 2000).

The exertional heat illness is associated primarily with signs and symptoms of dehydration followed by flushed skin, weariness, cramps, and apathy. At greater water deficits, dizziness, headache, vomiting, nausea, heat sensations on the head or neck, chills, decreased performance, and breathlessness may be present. (Armstrong and Maresh, 1993; The American Journal of Sports Medicine, 2007; Inder *et al.*, 1998; Rico-Sanz *et al.*, 1996; Smith, 2000)

Shortness of breath as part of high levels of activity like exhaustive exertion or during environmental conditions such as high altitude or very warm or cold temperatures (Bozkurt, 2003). Banister (1990) have reported about the excessive exercise that it is associated with hyperammonemia,

which could be responsible for exercise fatigue, motor in-coordination, ataxia, and stupor. In female athletes, due to excessive exercise, disordered eating, menstrual dysfunction, and osteoporosis are found named together as the "female athlete triad." (Deimelmd and Dunlapmd, 2012).

It is hypothesized that high-intensity training, with insufficient rest, leads to muscle or joint trauma. The injured tissue releases cytokines which activates to circulating monocytes, that in turn produce large quantities of pro-inflammatory factors viz. IL-1b, IL-6, and TNF-a, producing a systemic inflammatory states that help in making adjustments of body. This adaptation causes up-regulation of gluconeogenesis, as well as de novo synthesis of acute-phase proteins, and produces a concomitant hyper catabolic state; altered immune response as well as sick behavior in players (Brewster *et al.*, 1995).

Overtraining syndrome (OTS) develops in athletes such as in marathon runners who undergo prolonged vigorous training are prone to upper respiratory tract infection due to altered immune response with an up-regulation of humoral immunity and suppression of CMI which is also associated with high volume/intensity training, as well as with excessive exercise (EE), (Smith, 2003).

Guidelines regarding Dose of Physical Activity/ Exercise

WHO recommends the minimum amount of physical activity for all age groups to maintain physical, mental, social health and enable healthy ageing and prevent NCDs under the Global action plan on physical activity 2018-2030. WHO suggested that quality physical education and supportive school environments can provide physical and health literacy for long-lasting healthy, active lifestyles. The intensity of different forms of physical activity varies between people and depends on an individual's previous exercise experience and their relative level of fitness Füzéki and Banzer (2018).

Health professionals and policymakers are trying to generate awareness about the guidelines of physical activity and promote the health benefits of physical activity via implement programs, practices, and policies to facilitate increased physical activity and to improve the health (World Health Organization, 2018).

Recent studies have demonstrated the U-shaped relationship between running doses and cardiovascular diseases and all-cause mortality (Lee *et al.*, 2014; Schnohr *et al.*, 2013; O'keefe and Lavie, 2013; Thompson, 2014). The Copenhagen City Heart follows up study on runners and nonrunners (Schnohr

et al., 2013) reported that the runners had an impressive 44% lower risk of mortality during follow-up, with an average 6-year extension in life expectancy. However, a U-shaped curve was noticeable for mortality with respect to running dose, with the peak benefit noted with slow-to-moderate running speeds. Very high doses of running, however, were associated with trends of worse survival compared with either non-runners or groups of low- and moderate-dose runners.

Ayurveda guideline for proper dosing of Physical activity/exercise

Ayurveda advocated that Physical activity (Vyayama) should be performed daily in moderate-intensity only to get the beneficial effects. It must be done to the level of half of the strength of the person (Balardha) daily after considering the following factors viz. Age (Vaya), Strength (Bala), Physique (Shariraprakriti), Habitat (Desha), Season (Kala), nature of food intake(Ashan), otherwise person gets affected by the disease (Thakarar, 2017) (S.Ci.24/48). After doing physical activity, the entire body should be massaged mildly.

Characteristics of moderate exercise (Balardha / Ardhashakti)

Acharya (2008) has described characteristics of moderate exercise as when Vayu (air) residing in the region of the heart comes up through the mouth, is the sign of half the strength of the person could be understood as deep breathing with the increased rate (Dwivedi *et al.*, 2016) (C.Su.7/32).

Signs of proper Vyayama

1. Sweating (Svedaagamah), 2. Increased respiratory rate (Svashavridhi), 3. Increased heart rate (Hridayoparodhaccha), 4. Feeling of lightness in the body (Gatranamlaghavam), 5. Dryness of mouth (Mukhasosha), 6. Exertion (Aayasa) (C.Su.7/33).

However, contemporary science makes the grading of exercise intensity in metabolic equivalents (MET). Activities with METs between 3.0 to 6.0 have been considered as moderate intensity, whereas below 3.0 to 1.5 low intensity, more than 8 as severe categories (Jetté *et al.*, 1990).

Grading of exercise according to Ayurveda

The person who is healthy and strong, taking unctuous (oily) food should perform the regular exercise of the following grade as per the season (Kunte and Navare, 2009)

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 (Ativayayama)- should not be performed in any season.

Vyayama with different intensity is advised in different seasons because the body strength (Sharir bala) does not remain the same all through the year; it varies with the seasons. Body strength is best (Srestha) in dewy (Hemant), winter (Shishira), moderate (Madhyam) in autumn (Sharat), spring (Basanta), and poor (Alpa) in summer (Grishma), rainy (Varsha) season (C.Su.6/8).

Ayurvedic scholars have observed 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 does not benefit equally from exercise.

All these descriptions of Ayurveda about the various factors to be considered while prescribing physical activity or exercise will be helpful in the determination of doses of physical activity as per the individual to get optimal benefits and to avoid harmful effects of excessive exercise.

CONCLUSIONS

Thus Ayurveda has observed and documented all the aspects about various biological effects of Physical activity, including beneficial as well as harmful along with the various factors to be considered while prescribing physical activity to avoid undue effects and get optimal benefit. Few recent researches have also reported the harmful effects of excessive physical activity, which are consistent with observations of ancient Ayurveda scholars.

So it is highly needed to appreciate the perspective of Ayurveda scholars about the harmful effects of excessive physical activity on health and explore the association of physical activity and fitness in relation to dose of physical activity in the form of mild, moderate and severe grade and its overall effect on health to ascertain that how much activity is needed to get the optimal health benefits. Ayurveda has mentioned excessive physical activity as an etiological factor in etio-pathogenesis of various disorders and its manifestation. Cohort studies could be performed to ascertain the association between excessive physical activity and disorders, which will further help in planning the guideline for Physical activity in relation to dose and duration of Physical activ-

ity.

REFERENCES

- Acharya, J. M. 2008. Ashtanga Sangraha of Vagbhatta with Shashilekha Commentary of Indu. Chaukhambha Sanskrit Series office. 2nd edition.
- Armstrong, L. E., Maresh, C. M. 1993. The exertional heat illnesses: A risk of athletic participation. *Medicine Exercise Nutrition and Health*, 2(3):125-147.
- Banister, E. W. 1990. Exercise-Induced Hyperammonemia: Peripheral and Central Effects, *REF. Int J Sports Med*, 11:129-142.
- Bozkurt, B. 2003. Shortness of Breath Circulation. 108:11-13.
- Brewster, S. J., O'connor, F. G., Lillegard, W. A. 1995. Exercise-induced heat injury: diagnosis and management. *Sports medicine and arthroscopy review*, 3(4):260-266.
- Casa, D. J., Armstrong, L. E., Hillman, S. K., Montain, S. J., Reiff, R. V., Rich, B. S., Stone 2000. National athletic trainers' association position statement: fluid replacement for athletes. *Journal of Athletic Training*, 35(2):212-224. J. A.
- Coverley, D. M. W. D., Veale 1987. Registrar, Academic Department of Psychiatry, Royal Free Hospital. *British Journal of Addiction*, 82:735-740. Exercise Dependence.
- Deimelmd, J. F., Dunlapmd, B. J. 2012. The Female Athlete Triad. *Clinics in Sports Medicine*, 31(2):247-254.
- Dwivedi, L. D., Dwivedi, B. K., Goswami, P. K. 2016. Charak Samhita of Agnivesha with Ayurvedadeepika commentary of Chakrapanidatta. Chowkhambha Krishnadas Academy. Varanasi. 2nd edition.
- Feldman, D. I., Al-Mallah, M. H., Keteyian, S. J. 2015. No evidence of an upper threshold for mortality benefit at high levels of cardiorespiratory fitness. *J Am Coll Cardiol*, 65(6):629-630.
- Füzéki, E., Banzer, W. 2018. Physical Activity Recommendations for Health and Beyond in Currently Inactive Populations *Int. J. Environ. Res. Public Health*, 15.
- Haskell, W. L., Lee, I. M., Pate, R. R., Powell, K. E., Blair, S. N., Franklin, B. A., Bauman, A. 2007. Physical activity and public health: Updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Medicine and Science in Sports and Exercise*, 116(9):1081-1093. PubMed] [Google Scholar.
- Howe, A. S., Boden, B. P. 2007. Heat-related illness in

- athletes. *The American Journal of Sports Medicine*, 35(8):1384–1395.
- Inder, W. J., Swanney, M. P., Donald, R. A., Prickett, T. C. R., Hellemans, J. 1998. The effect of glycerol and desmopressin on exercise performance and hydration in triathletes. *Medicine and Science in Sports and Exercise*, 30:1263–1269.
- Jetté, M., Sidney, K., Blümchen, G. 1990. Metabolic equivalents (METs) in exercise testing, exercise prescription, and evaluation of functional capacity. *Clinical Cardiology*, 13:555–65.
- Kunte, A. M., Navare, K. S. 2009. *Ashtanga Hridaya of Vagbhata with Sarvangasundara commentary of Arundatta*. Varanasi. Chaukhambha Sanskrit Sansthana. Reprint edition.
- Lavie, C. J., null Md, Keefe, J. H., null Md, Sallis, R. E., null Md, Facsm, E., null Heart 2015. Harm of Too Little and Too Much Current Sports Medicine Reports. 14(2):104–109.
- Lee, D. C., Pate, R. R., Lavie, C. J., Sui, X., Church, T. S., Blair, S. N. 2014. Leisure-time running reduces all-cause and cardiovascular mortality risk. *Journal of the American College of Cardiology*, 64:472–81.
- Mandsager, K., Harb, S., Cremer, P., Phelan, D., Nissen, S. E., Jaber, W. 2018. Association of cardiorespiratory fitness with long-term mortality among adults undergoing exercise treadmill testing. *JAMA Netw Open*, 1(6):183605–183605.
- O'keefe, J. H., Lavie, C. J. 2013. Run for your life... at a comfortable speed and not too far. *Heart*, 99:516–525.
- Pedersen, B. K., Saltin, B. 2006. Evidence for prescribing exercise as therapy in chronic disease. 16:3–63.
- Rico-Sanz, J., Frontera, W. R., Rivera, M. A., Rivera-Brown, A., Mole, P. A., Meredith, C. N. 1996. Effects of hyperhydration on total body water, temperature regulation, and performance of elite young soccer players in a warm climate. *Int J Sports Med*, 17:85–91.
- Schnohr, P., Marott, J. L., Lange, P. 2013. Longevity in male and female joggers: the Copenhagen City Heart Study. *Am. J. Epidemiol*, 177:683–692.
- Schnohr, P., O'keefe, J. H., Marott, J. L., Lange, P., Jensen, G. B. 2015. A dose of jogging and long-term mortality: The Copenhagen City heart study. *Journal of the American College of Cardiology*, pages 411–419.
- Smith, L. L. 2000. Cytokine hypothesis of overtraining: a physiological adaptation to excessive stress? *Med. Sci. Sports Exerc*, 32(2):317–331.
- Smith, L. L. 2003. Excessive Exercise Overtraining and Altered Immunity *Sport Med*. 33:347–364.
- Thakarar, K. K. 2017. *Sushruta Samhita of Sushruta with Nibhandhasagraha commentary of Dalhan*. Varanasi. Chaukhambha Orientalia. Reprint edition.
- The American Journal of Sports Medicine 2007. American Orthopaedic Society for Sports Medicine. 35(8).
- Thompson, P. D. 2014. Increased cardiovascular disease mortality associated with excessive exercise in heart attack survivors. *Mayo Clinic Proceedings*, 89:1187–94.
- Vina, J., Sanchis-Gomar, Martinez-Bello, M. C., Gomez-Cabrera 2012. Exercise acts as a drug; the pharmacological benefits of exercise. *Br J Pharmacol*, 167(1):3448908–3448908.
- World Health Organization 2018. Global action plan on physical activity 2018–2030: more active people for a healthier world. . License: CC BY-NC-SA 3.0 IGO.