WORLD JOURNAL OF PHARMACEUTICAL RESEARCH
SJIF Impact Factor 8.074
Volume 8, Issue 7, 2002-2013. Review Article ISSN 2277– 7105

COMPARATIVE STUDY OF THE MECHANISM OF ACTION OF PRANAYAMA AND SWIMMING ON PULMONARY FUNCTION IN HEALTHY INDIVIDUAL –A REVIEW

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Article Received on 20 April 2019,
Revised on 10 May 2019,
Accepted on 31 May 2019
DOI: 10.20959/wjpr20197-15128

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ABSTRACT

Yoga an ancient science is very much helpful to bring balance and health to the physical, mental, emotional and spiritual dimensions of the individual. Maharshi Patanjali comprise the eight branches of Yoga as Yama, Niyama (Ethical practices), Asana (Posture), Pranayama (Breathing practices), Pratyahara (control over senses), Dharana, Dhyana (Meditation) and Samadhi of which Pranayama is the fourth branch. Swimming is one of the endurance exercise which is effective on cardiovascular and respiratory system and test the responses of these system is very popular. In swimming there is also a breath holding procedure. That's why the study was aimed to review the literature about the effect of Pranayama and swimming on lung function by means of total lung volumes and capacities and to compare the mechanism of action of both the modalities on that. **Conclusion**: It was concluded that both the modalities Pranayama and Swimming are significantly increases the pulmonary functions but as swimming is an endurance exercise it improves the lung function more effectively than the Pranayama which is a slow and steady method of breathing practices.

KEYWORDS: Lung function, Swimming, Pranayama, physiology etc.

INTRODUCTION

Yoga an ancient science is very much helpful to bring balance and health to the physical, mental, emotional and spiritual dimensions of the individual. Maharshi Patanjali comprise the eight branches of Yoga as Yama, Niyama (Ethical practices), Asana (Posture), Pranayama

(Breathing practices), Pratyahara (control over senses), Dharana, Dhyana (Meditation) and Samadhi of which Pranayama is the fourth branch.[1]

The word Pranayama is made up of two words “Prana” and “Ayama”. Prana means breath, respiration, life, vitality, oxygen, energy or strength. Ayama means lengthen, expand, stretch or restrain. This means the control over breath is Pranayama. Patanjali define Pranayama as after the mastery over asana controlling the inspiration and expiration is Pranayama.[2]

Pranayama aerates the lungs, removes phlegm and enhances lung compliance. It soothens the nerves and tone up the whole body system. It enhances the digestive power and cleans the sinuses.[3]

In today’s modern era due to increased globalization, industrialization and automobiles, pollution is increased because of which the prevalence and incidence of respiratory diseases like Allergic rhinitis, Asthma, Chronic obstructive pulmonary diseases (COPD) etc. are increased very much. Due to pollution lung volume and capacities are decreased very much which leads to the chronic respiratory diseases. With the help of Pranayama we could enhance the lung capacity and volumes and could enhance the lung function.

Swimming is one of the endurance exercise which is effective on cardiovascular and respiratory system and test the responses of these system is very popular. In swimming there is also a breath holding procedure. That’s why the study was planned to review the literature about the effect of Pranayama and swimming on lung function by means of total lung volumes and capacities and to compare the effect of both the modalities on that.

AIM AND OBJECTIVES

1. To review the literature about the effect of Pranayama and swimming on lung function.
2. To review the literature about the physiology of Pranayama and Swimming

METHODOLOGY

An Ancient and Modern literature and Studies regarding the Pranayama and Swimming have been studied. The Critical review and Comparison has been done regarding the Mechanism of action and effect of Pranayama which is a slow and steady method of breathing with that of Swimming which is a fast and rigorous type of exercise.

Why to perform Pranayama?

When Pranvayu (air) is moving the mind will be unstable and when the Pranvayu becomes stable mind also attain stability. When both Pranvayu and mind is stable then only Yogi can attain Sthanutva. Hence one should perform Pranayama to control vayu.[4]

The person is said to be live whenever the Pranvayu is present in our body and when the Pranvayu goes out of the body the person becomes dead. Hence for the longevity of life one should control vayu.[5]

When the Pranvayu goes inside the Sushumna nadi (central channel) one can attain Manosthairya (Stability of mind) that is also called as chittasya(mind) unmani bhava. For the attainment of this stability of mind one should perform different types of Kumbhaka(retention of breath). By the practice of kumbhaka there is the attainment of different Siddhi.[6]

Types of Pranayama

Patanjali emphasized three different vruttis viz. Bahya Vritti, Abhyantar vritti and Stambha Vritti.[7] Further he also mentioned that there is fourth type i.e. the Pranayama which could be performed devoid of inspiration and expiration is the fourth one.[8]

1. Bahyavritti i.e. Rechaka or expiration or emptying the lungs.
2. Abhyantarvritti i.e. puraka or inspiration or filling up the lungs.
3. Stambhavritti i.e. Kumbhaka or with holding breath.

Acharya Patanjali comprises three different criteria of (1) Desh (2) Kala and (3) Samkhya for Puraka, Kumbhaka and Rechaka. Further he mentioned that the Dirgha and Sukshma are the differentiating features of the cycle of Pranayama. Swami Omananda Tirtha, a well known commentator on Patanjali Yoga Pradip, has mentioned three types of Pranayama as stated earlier. However he has sub-classified each of these types of Pranayama (i.e. Bahyavritti, Abhyantar Vritti and Stambha Vritti) into three types. They are Desh, Kala and Samkhya.[7]

Desh comprises the part of the body, it can be elaborated as Rechaka (Expiration) should be done till the exhaled air reaches up to the nostrils, Puraka (Inspiration) should to be done till the inhaled air reaches up to Muladhara (Rectum) region. Kala means the particular time required for Puraka, Rechaka and Kumbhaka. Samkhya comprises that how continuously the particular Pranayama could be done for a particular numbers of the times.

Hatayoga Pradipika described the Kumbhaka as a synonym of Pranayama. Eight types of Kumbhaka are mentioned there i.e.[9]

1. Suryabhedi 5. Bhastrika
2. Ujjayi 6. Bhramari
3. Sitakari 7. Murchha
4. Shitali 8. Plavini

In certain Granthas Kumbhaka are classified in to two types viz.

1) Sahita
2) Kewala

Sahit is further classified as eight types as mentioned above & Kewala Kumbhaka is described as a process of Pranayama devoid of Rechaka & Puraka and it is the most difficult type of Kumbhaka. It is further mentioned that, the Kundalini Shakti gets activated in Yogi who performed Kewala Kumbhaka successfully.[10]

Further they also mentioned that Prana can be achieved either directly or indirectly. When it is direct it is called Kumbhaka. That is also of two types. That which can be practiced by means of the regulation of place, time and number is called Sahita Kumbhaka. When there are no such regulations, but the motion of Prana is paralyzed at once, by the sheer force of which is called Kewala Kumbhaka.

In Gheranda Samhita they explain the Sagarbha Pranayama as sitting in Sukhasana posters facing the East or the North, contemplating on Bramha associated with rajas, red in color and characterized by the letter "A" of (Om).[11]

Further they mentioned that, Yogi should inhale through left Nostril for upto 16 mantra and after inhalation and before cessation of breath let him perform Uddiyanaka. Then contemplating on Hari associated with satva of dark complexion and characterized by the letter "U" of (Om) and perform Kumbhaka upto 64 mantra.[12]

Further they mentioned that contemplating on Shiva associated with tamas of white color and characterized by the letters "M" inhale by right Nostril upto 32 mantra.[13]

This procedure should be done by the Right Nostril also i.e. starting Puraka with right Nostril then Kumbhaka & again Rechaka should be done by Left Nostril as above.

Mechanism of Action of the Effect of Pranayama

Breathing practices during Pranayama constitute volitional control of breathing. It influences the vital systems of the body. Apart from the mind and the intellect, it also developed the steady state of vital systems like cardiac, nervous and respiratory system. As the unutilized energetic sources are mobilized, these systems get restricted to the reaction of stress stimuli.[14]

The slow, smooth and prolonged breathing tranquilizes the mind. The calm, quite and tranquil mind avert needless reaction of Cardio-Vascular System to the stress stimuli. Pranayama also stimulates cerebral circulation and improve the brain function and thus relieving the mental stress. Pranayama exerts its effects on hypertension and controls it up to some extent.[14]

The Pranayama also influences the lung circulation favorably influencing the lung ventilation and perfusion ratio. This improves the cardiac output by 20%.The vital index considerably increases through the regular practice of Pranayama.[14]

The Pranayama serves the purpose of increasing the oxygen consumption with minimum physical efforts with the remarkable increase in breath holding time. It is definitely beneficial for the cardio – vascular system. It is also reported that increase in oxygen consumption was observed in Kapalbhati, and Ujjayi Pranayama (Dr. Kavoor et al 1937).[14]

There is a strengthening of respiratory musculature due to Pranayama practice as the lungs inflate and deflate fully as possible and muscles are made to work to the maximal extent and hence the lungs volume and capacities get improved.[15]

The maximum inflation and deflation is an important physiological stimulus for the release of surfactant and prostaglandins increasing the alveolar spaces thereby increasing lung compliance and decreasing bronchial smooth muscle tone activity. The yogic processes of performing Pranayama in fixed posture breathing through alternate nostrils promote vertical breathing. By this vertical breathing all the alveoli of both the lungs open out evenly.[15]

The diaphragm descents 1.5cm during quiet breathing, but during deep vertical breathing it descents 6 to 7 Cm, increasing vertical diameter of thoracic cavity.[16]

Total diaphragmatic surface is 270 Cm2; every 1 Cm descent of diaphragm will increase the thoracic cage cavity by 270 cc with an intra pulmonary pressure of -3 mmHg. During deep breathing diaphragm descends as a result intra pulmonary pressure will become about -6 mmHg facilitating more air entry into the lungs improving vital capacity.[16]

By regular practice of Pranayama respiratory centre in medulla oblongata is brought under volition. In Pranayama the individual continues the phase of inhalation with his strong voluntary control so that lungs are expanded considerably and the walls of the alveoli are stretched to the maximum thus the chest continues to get expanded under cortical control. The stretch receptors are thus trained to withstand more and more stretching this helps us to hold the breath for a long period. The duration is gradually increased so that respiratory centre is gradually acclimatized to withstand higher Pco_2 and lower Po_2. The CO_2 stimulates the chemo receptors located in the medulla oblongata that are sensitive to the amount of CO_2 concentration in blood, which in turn send the impulses to the respiratory centre. The respiratory centre which could have otherwise started exhalation is now helpless against the strong voluntary control from the cortex, so in many ways the individual practicing Pranayama is training the chemoreceptor to tolerate more and more tensions. As the CO_2 goes on accumulating during breath holding, the chemo receptors report it promptly to the pneumotaxic centre which in form tries to stimulate expiratory centre. The autonomic or the reflex mechanism of respiration is more powerful than the control from higher centers that is why after a particular stage it is not possible to hold the breath further. The receptors get acclimatized to the increased concentration of CO_2 gradually by regular practice of Pranayama.[17]

The respiratory centre is under the voluntary control and the respiration can voluntarily arrested for a variable period during any phase of respiratory cycle by inhibitory impulses from higher centers which are able to balance excitatory effect of other afferents. At the end of breath holding these excitatory impulses increase the sensitivity of the centre to such a level that the voluntary control finally breaks and the respiration commences. Increased tolerance to higher Pco_2 and low Po_2 achieved due to training could prolong breath holding time in Pranayama practitioners.[17]

Swimming

Swimming can be enjoyed by young and old alike, individually or in groups, Once you know how to swim you can take part in many other activities, such as water polo, synchronized swimming, diving, sub aqua, competitive swimming and all water-based sports, among which sailing and canoeing are very popular.

Swimming is also a very healthy activity, because it exercises all your muscles and keeps your body in tune. Many doctors recommend swimming for overcoming commonplace ailments or for getting your strength back after an injury.

When to Start

It is never too early or too late to learn to swim. The younger you start the better, because this is when you learn quickest, but people in their seventies can learn to swim very successfully. Babies may be introduced to the water only months after their birth, as long as the water is warm. (Cold water is dangerous as it takes away the baby's natural body heat). Children of two, three or even younger can be taught the basic swimming skills and encouraged to move through the water unaided. But if you can't swim already, the time to start is now, whatever your age.[18]

Rules of Safe Swimming

1. Stay in your depth until you have learned to swim.
2. Try to a make sure that you never swim alone. if you get into trouble you may need help.
3. If you wear an aid, make sure that it fits comfortably and does not restrict your movements.
4. Take care when walking near a swimming pool, because the side is often wet and slippery. Don't run or jostle people.
5. Never eat or chew anything while swimming as this could be dangerous, and never swim on a full stomach. After a heavy meal you should wait for at least an hour before swimming, to allow time for digestion.
6. Never duck anyone under the water. This could frighten a beginner and damage his confidence.
7. Never pretend to be drowning. Remember what happened to the boy who cried 'Wolf!' once too often.
8. If you do swim in the sea, be very careful when using a rubber ring. You could be carried away from the shore very quickly by a current.
9. Take care to dry yourself thoroughly after each swim, to avoid colds and chills.
10. Everyone likes to swim in water that is clean, so you should always have consideration for others when you use a swimming pool. Before entering the water visit the lavatory,

take a shower, if one is provided, and wash your feet in the footbath. Never go swimming if you have an infection or an open sore.[18]

Where to Swim

It is important that your first experience of the water is enjoyable so the best and safest place for learning to swim is your local swimming pool. Of course, it is possible to swim in the sea, rivers, canals, lakes or ponds, but these places are seldom suitable for beginners because of hazards such as currents, weed, sudden changes of depth and cold water. The water temperature in the swimming pool will be 26-29^{o} C, which is ideal for learning to swim, and you will be able to relax and concentrate on making the right movements.[18]

Physiology and Mechanism of action of Swimming

The propulsion during whole body swimming is generated by the action of both arms and legs. Therefore, daily swimming training is conducted not only by whole body swimming but also by arm stroke or leg kicking only, because it has been considered that to strengthen metabolic capacity in local muscles would improve more effectively whole body swimming performance. Therefore, if time dependent metabolic demands of arm stroke (A), leg kick (K) as well as whole body (S) swimming are clarified, the knowledge would provide an important implication for specific training of each distance event. So, the aerobic and anaerobic energy release were determined at six different intensities, which were estimated to cause exhaustion in 15 s, 30 s, 1 min, 2-3 min, 4-5 min, and 8-10 min simulating from 25m sprint to 800m.

Aerobic and anaerobic energy release

The accumulated O_2 uptake (AOU) increased linearly with exercise time in all strokes. This means that the longer the duration (and thus the distance), the larger the total amount of aerobic energy release. Also, the increased rate of AOU related to exercise duration was the highest in whole body swimming (S), and those in arm stroke (A) and leg kick (K) corresponded to 70 and 80% of that in S, respectively. The ratio was similar to those when VO2max among strokes was compared (A: 2.80 l•min^{-1}, K: 3.34 l• min^{-1}, S: 3.92 l• min^{-1}). Therefore, it is suggested that the increased rate of AOU is highly dependent on the magnitude of VO2max, supporting a general concept that a higher maximal aerobic power can be more beneficial to accomplish a good performance for the endurance swimmer. With increasing duration, the AOD in A and S significantly increased until 2-3min of exercise, and the accumulated O_2 deficit (AOD) gradually decreased when the exercise duration was longer than 4-5min. The AOD at 30s was not significantly different from those at 1 min and 2-

3min.[18] Several studies used running and cycling have also reported that the AOD reached maximal levels with exercise bouts lasting 2-3 min. Actually, it was revealed that the anaerobic ATP production estimated by lactate production and PCr break down was the highest in 2-3 min exhaustive exercise (Medbø 1993). These findings indicate that both the ATP- PCr system as well as the lactate producing system are stressed maximally with 2- 3 min exhaustive exercise. Therefore, it is suggested that the anaerobic energy system is recruited maximally in 200m swimming event, and consequently maximal AOD (MAOD) is recognized as an important factor determining the performance of this event. On the other hand, the AOD in K increased more rapidly, and reached almost maximal levels in 30 s (>90% of maximal AOD). In addition, this level was observed in bouts lasting up to 2-3 min. Therefore, it is implies that the anaerobic energy release in K is different from the other strokes and that the swimmer can induce a maximal stimulus for the anaerobic energy process in leg muscles by maximal leg kicks of 50 m to 200 m. Consequently, this stimulus would induce the improvement of the anaerobic capacity in K, due to an increase in buffering capacity of leg muscles *per second*.[19]

Effects of Training Modes (or Intensity) on Vo2max and MAOD

Metabolic capacity has been considered to be one of important determinants of swimming performance. Therefore, the swimming training should be designed to improve the ability to release energy both aerobically and anaerobically. The most popular training regimens in competitive swimming are an intermittent (interval) training and a continuous (endurance) training. In general, the success of the training effect can and should be evaluated not only by an exercise performance but also by metabolic capacity such as VO_2max and MAOD. So, we compared the specific training effect of different training protocols: a moderate-intensity endurance training and high-intensity intermittent training. In this study, continuous training (CT) was performed at the intensity of 70% VO_2 max for 60 min•session-1, on the otherhand, intermittent training (IT) consisted of 7-8 sets of 20-s exercise at an intensity of 170% VO_2max with a 10-s rest between each bout. Both trainings were done 5 days a week for 6 weeks.

The Effect Swimming on VO2max and MAOD

After the training, VO2max increased from 53 to 58 ml•kg- 1•min-1 in CT, and 48 to 55 ml•kg-1•min-1 in IT. On the other hand, MAOD did not increase significantly in CT, but it increased by 28% in IT. These results indicate that CT at moderate- intensity can improve aerobic power but not MAOD and that IT at high-intensity can improve both VO2max and MAOD simultaneously.

These results suggest that CT at moderate-intensity is not intense enough training to improve anaerobic power. In fact, it has been proved that the used IT training protocol can tax maximally stimulus not only to aerobic but also to anaerobic energy process but that CT at moderate intensity does not (Tabata. 1996). As previously suggested, the greater stimulus to aimed energy system, the larger improvement of metabolic capacity. Accordingly, for short to middle distance swimmers who are proposed to be strengthened both energy processes, IT at high intensity must be more adequate training mode compared to CT at moderate intensity.[19]

Energetics In Supramaximal Swimming Under Hypoxic Conditions

It has been well documented that VO_2max reduces with decrease in atmospheric pressure, i.e. O2 fraction. In addition, several investigations have shown that hypoxia results in slower O2 uptake kinetics during exercise (Engelen 1996, Hughson 1995). Since steady-state VO_2 during submaximal exercise is identical between normoxic and hypoxic conditions, this means that AOD is greater in hypoxia than in normoxia (Knuttgen 1973, Linnarson 1974). Indeed, a greater reduction in muscle phosphor creatine levels and greater increases in blood and muscle lactate concentrations have been observed during submaximal exercise in hypoxia compared with normoxia (Knuttgen1973, Linnarson 1974).

V**O2max in each condition**

VO2max was significantly reduced as atmospheric pressure decreased. Compared to mean values of VO2max at sea level (4.28±0.53 l•min^{-1}), values were at 96% for 800 m (4.11±0.49 l•min^{-1}), 88% for 1600 m (3.76±0.44 l•min^{-1}), and 85% for 2400 m (3.63±0.44 l•min^{-1}).[19]

Aerobic and Anaerobic energy release during Supramaximal exhaustive Swimming

Mean water flow rate in the supramaximal swimming diminished significantly with decreased atmospheric pressure. However, when O2 demand estimated from water flow rate was expressed as a percentage of VO2max, no significant differences were observed. This means that even though absolute exercise intensity in hypoxic condition decreased due to a decrease in VO2max, the swimmers could swim relatively at the same intensity. VO2 during the supramaximal swimming quickly increased at the beginning of exercise and almost reached a plateau within 2 min in all conditions. However, mean VO_2 determined every 30 s as well as VO_2 peak decreased with increasing hypoxia, and thus AOU tended to decrease with increased altitude (although no significant differences were identified). Also decrease in VO_2 peak under hypoxic conditions was quite comparable to the decrease in VO_2max under each hypoxic condition. Therefore, VO_2 during supramaximal exercise also appears to be directly affected by the level of hypobaric hypoxia throughout the exercise. Conversely, changes in O2 deficit determined every 30 s during the bout were quite comparable in all conditions. Consequently, no significant differences were observed in MAOD between the conditions. This implies that the rate of anaerobic energy release during exercise is strongly associated with relative physiological stress regardless of inspiratory O_2 fraction, although underlying mechanisms remain unclear.

Time course of VO_2 and O_2 deficit measured every 30 s during supramaximal swimming under normal (sea level) and hypobaric hypoxic conditions corresponding to 800 m, 1600 m and 2400 m above sea level. (Ogita 2000) Our results suggest that during supramaximal swimming, rate of aerobic energy release diminished with increase in hypobaric hypoxia, while not only AOD but also rate of anaerobic energy release throughout the exercise were unaffected despite the decreased O2 demand caused by diminished exercise intensity due to hypobaric hypoxia. If so, hypoxic condition such as high altitude might be a better condition to tax easily a greater stimulus to anaerobic energy process regardless of the decrease in absolute exercise Our results suggest that during supramaximal swimming, rate of aerobic energy release diminished with increase in hypobaric hypoxia, while not only AOD but also rate of anaerobic energy release throughout the exercise were unaffected despite the decreased O2 demand caused by diminished exercise intensity due to hypobaric hypoxia. If so, hypoxic condition such as high altitude might be a better condition to tax easily a greater stimulus to anaerobic energy process regardless of the decrease in absolute exercise intensity.[19]

CONCLUSION

It was concluded that both the modalities Pranayama and Swimming are significantly increases the pulmonary functions but as swimming is an endurance exercise it improves the lung function more effectively than the Pranayama which is a slow and steady method of breathing practices.

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