CHAPTER - II
REVIEW OF RELATED LITERATURE

The study of relevant literature is an essential step to get a clear idea of what has been done, with regard to the problem under study. Such a review brings about a deep and clear perspective of the overall field. The research for reference material is a time consuming but fruitful phase of the research programme. A familiarity with the literature in any problem area helps the researcher to discover what is already known, what others have attempted to find out, what methods have been promising disappointing, and what problems remain to be solved.

The literature in any field forms the foundation upon which all future work will be built. The reviews of literature are generally used as a basis for inductive reasoning for locating and synthesizing all the relevant literature on a particular topic. A serious and scholarly attempt has been made by the scholar to go through the related literature and a brief review of the studies related to the present problem is described in this chapter. The present chapter covers the relevant available literature pertaining to the present study.

Corry I et al. (1982) studied the maximal aerobic power in runners and swimmers. They used five cross country runners and five competitive swimmers who performed a pulling exercise with the elastic shock and a treadmill run to exhaustion. They observed that the man VO$_2$ max related to lean body mass of runner was significantly higher than the swimmers in the treadmill (P less than 0.05) while in the pulling test, the mean VO$_2$ max swimmers was significantly higher than the runners (p less than 0.01). They found that the maximum heart rates achieved pulling were 95% of the running maximum by runners and 96% by swimmers with no significant
differences between them. They also found that mean oxygen pulse of swimmers and runners was almost the same for maximal running but swimmers have significantly higher oxygen pulse than the runner for maximal pulling (p less than 0.01). Further, the swimmers reached about 79% of their running VO$_2$ max by pulling while the runners used 53% of their running VO$_2$ max.

Barlett HL et al. (1984) studied the relationship between body composition and expiratory reserve volume in female gymnasts and runners. The aim of present study is to demonstrate the smaller ERV values in lean female athletes with greater than normal body muscle development. They used members of two collegiate women’s teams—gymnastics (N=10) and track (N=10), whose ERV, VC and segmental body volumes were measured by densitometry. Runners were similar to gymnasts in age, weight and body fatness but runners were not engaged in upper body weight training or gymnastic exercises. They found ERV was significantly less in gymnasts (means +/-SD=29.7+/-7.1) than in runners (43.1+/-6.4), other lung capacities as volumes were comparable in both groups. Further arm and thorax volumes indicated greater upper body six in Gymnasts. (Arm volume, means +/-SD of G=4.8+/-.6L, of R=4.0+/-.6L, P<0.01) (Thorax volume, means +/-SD of G=7.8+/-1.4L of R=5.6+/-1.0L, P<0.001).

Wang YT et al. (1986) assessed lung function and respiratory muscle, strength after propranolol in thyrotoxicosis. They used 35 thyrotoxic patients and assessed them before treatment after treatment with propranolol and after antithyroid drugs. They performed three assessment points on first group of patients(n=17) including FEV, VC, FRC, RV, TLC, MMFR, DLCO, PImax and PEmax and Arterial blood gas analysis. They found no significant changes in FRC, RV, TLC, MMER, DLCO and blood gases either after propranolol or after antithyroid drugs. For second group (n=18). They performed FEVI, VC, PImax and PEmax only. They found that only PImax was
significantly improved after propranolol (from 46.5+/−16.5 to 53.2+/−22cmH2O, P<0.01). They suggested that adrenergic excess was playing role in thyrtotoxic inspiratory muscle weakness. They also found significant increase in PI max, PE max, FEVI and VC after antithyroid drugs.

Zinman R et al. (1986) determined relationship between the growth of lung volumes and development of maximal static pressures by examining 1 year follow up study of 17 female swimmers less than 12 years of age. They measured lung volumes by body plethysmography. Maximal static Inspiratory and expiratory pressure generated near residual volume at functional residual capacity and near total lung capacity. They compared the results with regressions obtained from cross sectional data generated on 59 girls from local school. They concluded that large lung volumes in swimmers cannot be accounted for by an increase ability to inflate and deflate the lung by the respiratory muscle. They found height to be similar, vital capacity and TLC to exceed normal limits in 11 to 17 swimmers, significant increase in Pmax in expiration near TLC in swimmers of less than 10 yrs. of age.

Bjurstrom RL et al. (1987) investigated the role of the control of ventilation and lung volume in elite synchronized swimmers volume in elite synchronized swimmers. They studied 10 members of National Synchronized swim team including on Olympic gold Medalist and 10 age-matched controls. They evaluated static pulmonary function, hypoxic and hypercapnic ventilator drives, normoxic and hyperoxic breath holding. They found that synchronized swimmers have high total lung capacity and vital capacity as compared with controls (P less than 0.005). They observed that the hypoxic ventilator response (expressed as the hyperbolic shape parameter A) in synchronized swimmers was lower than controls with a mean value of 29.2 +/- 2.6 (SE) and 65.6 +/- 7.1, respectively (P less than 0.001). However there
was no difference in the hypercapnic ventilator response [expressed as S, minute ventilation (1/min)/alveolar CO₂ partial pressure (Torr)] of synchronized swimmers and controls. They found that there was no difference in hyperoxic breath hold times between groups, but breath hold duration during normoxia was greater in synchronized swimmers. They concluded that intense swimming activity causes a greater than normal lung growth irrespective of presence of allergic sensitization or airway hyper responsiveness. The decrease in FEV (1)/FVC cannot be considered as true obstructive abnormality, it was just a physiological variant.

Clanton TL et al. (1987) studied the effects of swim training on lung volumes and inspiratory muscle conditioning. They measured lung volumes and inspiratory muscle function tests in 16 competitive female swimmers (age 19+/−1 yr) before and after 12 week of swim training. Eight underwent additional in training, the remaining eight were controls. They found increase in VC 0.25+/−0.25L (P<0.01), FRC0.39+/−0.29L(P<0.001), TLC 0.35+/−0.47(P<0.025) in swimmers irrespective of IM training. They found no change in RV. They also found change in PImax measured at FRC -43+/−18cmH₂O (P<0.005) in swimmers with IM conditioning and -29+/−25(P<0.05) in controls. They concluded that 65% of pre study PImax could be endured in increased in IM trainer (P<0.001) and controls (P<0.005). They compared the results with IM training in normal females and found significant increase in PImax. They observed endurance in IM trainer’s. They observed endurance in IM trainers only with no changes in VC, FRC or TLC. They concluded that swim training increases VC, TLC and FRC with no effect on RV in mature females. They also concluded that endurance measured near FRC and IM strength increases due to swim training.

Vincken WG et al. (1987) studied two groups of 10 nonsmokers with stable, chronic neuromuscular disease but without respiratory
symptoms in order to identify the changes in pulmonary function and in the flow volume loop due to respiratory muscle weakness. They assured Group 1 (without) and Group 2 (with) respiratory muscle weakness by measurement of maximal static inspiratory and expiratory pressures. They found pulmonary function to be normal in Group 1 expect for increased ratio of FEVI to FVC and forced expiratory flow at 25-75% forced vital capacity which clearly indicated increased elastic lung recoil. They also found mild volume restriction and reduced expiratory and inspiratory flow rates in Group 2. They evaluated that pulmonary function was significantly more disturbed in Group 2 than in 1 and well correlated with maximal static inspiratory and expiratory pressures. They also found significantly higher score of flow volume loop in group 2 than in group 1 (2.8 +/- 1.03 versus 1.1 +/- 1.37; P<0.01). They suggested that sensitive assessment of the flow volume loop configuration as part of pulmonary function testing help to suspect and identify respiratory muscle weakness. The flow volume loop score of 2 or more had 80% specificity and 90% sensitivity in predicting respiratory muscle weakness in patients with chronic neuromuscular disease.

Palacios S et al. (1989) assessed pulmonary function and respiratory muscle strength in 20 patients with mitral stenosis. They evaluated pulmonary function by spirometer, flow volume curves, FRC and TLC. They evaluated Respiratory muscle strength by measurement of maximal static inspiratory and expiratory mouth pressure at FRC and TLC respectively. They found spirometric, FRC and TLC average values were normal. They also found decrease in maximal expiratory flow rate at 50 and 25% of vital capacity to 49.5 and 38.3% from predicted values. They found similar values of PIM and PEM in patients and 12 normal subjects who were studied at comparable lung volume. Their results were similar to previous reports and there was no evidence of decreased respiratory muscle force.
Pherwani AV et al. (1989) studied the pulmonary function of competitive swimmers. They compared the pulmonary functions tests (PFT) of 45 swimmers (who swam a distance of 2 to 5 kms per day regularly) with age, sex, height and weight matched controls. They measured VC, IRV, FVC, FEVI and V25, effect of the periods of training on PFT’s was also analysed by them. They found that VC, IRN, FVC, FEVI and V25 were higher in swimmers (s) than controls (NS) by 20%, 25%, 37.4%, 30.1% and 15.1% respectively. They observed that inspiratory capacity was significantly higher in Gr IS than NS because of reduction in FRV, FVC and FEVI were higher in Gr II than NS. They have seen large differences between Gr IV S and NS where FVC, FEVI, V75 and PEER were higher by 50.2%, 38.2%, 69.4% and 25% respectively in S than NS. These differences were because of hypertrophy of the diaphragm which required had work for prolong period. Further expiratory flows the rate and MMV showed significantly higher values at HA in both groups. They also found that after air density correction for 2 attitudes, PEF and MMV showed no changes from their baseline values and the mid expiratory flow rate (FEF(25-75%)) was actually reduced in both groups in day 2 in Kyrgyzis and on day 25 in the Indians. They conducted that the major differences between the 2 populations was the larger lung volumes in the Kyrgyzis compared with the Indians with no difference seen their flow rates. They also reported that there was a different time schedule of altitude- induced reduction in FVC and FEF (25-75%).

Vanderschueren D et al. (1989) studied pulmonary function and maximal transrespiratory pressure in ankylosing spondylitis. They used 30 patients /age 43 (SD10) years for their purpose. They reduced vital capacity slightly to 79(16%) and FEVI also to 82 (20%) such that their average FEVI/VC ratio was 77.8(6.65) They also reduced TLC to 85(13%), TLC to 88(17%) and TLCO per unit lung volume to 114(26%) They correlate reductions in lung volumes with clinical measurements. PE max and PI max was also clearly reduced
to 56(17%) and 76(28%) respectively. They suggested that spirometrically determines volumes were better preserved than respiratory muscle strength in ankylosing spondylitis. They speculated that the reduction in respiratory muscle strength may be due to intercostal muscle atrophy.

Cordain L et al. (1990) determined whether respiratory muscle strength is related to pulmonary volume differences in athletes and non-athletes. They evaluated pulmonary parameters including maximal inspiratory pressure (PI max) and maximal expiratory pressure (PE max) of 11 intercollegiate female swimmers, 11 female cross country runners and two non athletic control groups, matched to the athletes in height and age. They found swimmers exhibited larger (p less than 0.5) vital capacities (VC), residual lung volumes (RV), inspiratory capacities (IC) and functional residual capacities (FRC) than both the runners and the controls. But no difference (p greater than 0.5) in either PI max or inspiratory flow (FIV 25-75%) was found between the groups. Further timed expiratory volumes (FEV 0.5 and FEV 1.0) were significantly (p less than 0.5) lower in the swimmer than in the controls. They concluded that an adaptation growth may be responsible in part for the augmented static lung volumes demonstrated in swimmers. Pulmonary function variables significantly increase with in all groups at the end of 12 week study. They demonstrated that there are no appreciable differences in terms of respiratory changes between elite swimmers undergoing a competitive ST program and those undergoing respiratory muscle training using the flow resistive IMT device.

Hill NS et al. (1991) studied the effects of an endurance triathlon (consisting of a 3.8 km swim, a 180 km bicycle side and a 42 km run) on pulmonary function. They assessed the forced expiratory spirogram, indices of inspiratory and expiratory muscle strength (PI max and PE max), maximal voluntary ventilation (MVV). The
participants are 12 males of average age 32.9 yrs. These participants underwent studies on the afternoon before the event, after each segment and on the following morning. They all completed the triathlon with an average finishing time of 12 h 45 +/- 90 min. They found that there was statically significant decline in FVC (7.1%), FEVI (8.4%), FEF 25-75% (15.2%), FEF 50% (18.6%) but no decline in MVV, following the completion of triathlon. They also observed than on morning after the triathlon only FEVI remain significantly below baseline, PI max was not significantly reduces after the bicycle and running events (26% and 25% respectively), PE max was remain unchanged (no significant change). They concluded that vital capacity, flow rates at mid lung.

Armour J et al. (1993) compared eight elite male swimmers, eight elite male long distance athletes and eight control subjects in order to obtain insight into mechanisms relating to large lung volumes of swimmers, lung dispensability (K) and elastic recoil, pulmonary diffusion capacity, respiratory mouth pressures together with anthropometric data (height, weight, body surface area, chest, width, depth and surface area). They also examined the difference in training profiles of each group. The swimmers were younger than runners and controls but both swimmers and controls were heavier than runners no significant difference in height between the subjects. The mean total distance in kilometers covered per week was significantly greater in runners were higher in swimmers 69.34+/−22.4pg/ml relative to non-swimmers(p<0.000), 1L-10 concentrations' were lower in swimmers 34.94+/−9.71pg/ml that static group (44.69+/−16.32pg/ m;p=0.027). They negatively correlated FEV(1%), FEF(25%), FEF(50%) and MMEF% with 1L-4 levels, but IL-10 levels were not correlated. They concluded that lung capacity of swimmers was greater than other athletes. They also observed small airway dysfunction in some swimmers and endurance athletes. They found correlation of lung
function measurement with sports, age, gender, height, weight in various athletes. They observed an association between systemic anaphylaxis and small airway dysfunction after prolonged regular training particularly following swimming and endurance training.

Convertino VA et al. (1993) determined studies whether fluids electrolyte, renal, hormonal and cardiovascular responses during and after multi hour water immersion were associated with the aerobic training. They compared these responses in trained hypogravic versus a 1-g environment. For comparison they used (seventeen men comprised three similarly aged groups)- six long distance runners, five competitive swimmers and six untrained control subjects. They immersed in each subjects in water for 5h with [mean SE] 36.0(0.5) degree C to the neck and immediately before and at each hour of immersion, they collected blood and urine samples and analyzed the samples for sodium (Na), potassium, osmolality and creatinine (Cr). They also measured heart rate response to sub maximal cycle ergometer exercise (35% peak oxygen uptake) before and after water immersion, plasma antidiuretic hormone and aldosterone. They used hematocrits to calculate relative changes in plasma volume (% delta vpl). They found significant increase in urine flow, Na clearance (CNa) and a 3-5% decrease in vpl by the water immersion. They concluded that swimmers experience a worsening of nasal function after training. These differences were only significant for post nasal drip. These result suggested the existence of a swimming- induced rhinitis independent of the atopic status of the athlete.

Merolo B et al. (1996) evaluated lung volumes and respiratory muscle strength in patients diagnosed as GH deficient before and after 6 and 12 months of recombinant GH treatment. The subjects selected for the study are ten adults diagnosed as GH deficient in childhood, ten adults diagnosed as GH deficient in adulthood and ten healthy subjects. For each subjects they evaluated respiratory
function followed the same standard approach, consisting of respiratory muscle strength assessment, record of flow volume curves, measurement of static lung volumes and lung diffusing capacity. They found significant reduction of maximal inspiratory (p<0.01) and maximal expiratory (p<0.05) mouth pressures in childhood onset GH patients. Total lung capacity, vital capacity, functional residual capacity were significant reduces as compared to healthy subjects (p<0.05). They observed no significant change in residual volume, diffusing lung capacity and ratio between the percentage forced expiratory volume in it and forced vital. After 12 months of treatment with recombinant GH. They concluded for adult onset GH patients an impairment of maximal expiratory pressure because of respiratory muscle weakness which can be re-established after 12 months of GH therapy.

Sahebjami H et al. (1996) determined pulmonary function test profile and inspiratory muscle strength of a group of obese individuals who do not have any respiratory problem. They took 63 consecutive amoles (BMI greater than 27.8 kg/m²) without overt obstructive airway disease (FFVI/FVC ratio greater than 80%). Standard PFTs and Plmax, Pmax were calculated, RMS was also calculated. They identified two groups first group with normal MVV (>80% predicted) and second group with low MVV. They found significantly lower values of inspiratory and expiratory flow at rates (FVC, FFVI, forced inspiratory flow at 50% vital capacity [V50], maximal inspiratory flow rate MIFR, lung volumes (VC, IC and expiratory reserve volume), Plmax and RMS in obese subjects with low MVV than normal MVV. They also found significantly higher ratio of RV/TLC in obese subjects with low MVV. They found correlation significantly with FVC, FFVI, V50, MIFR, TLC VC, IC, RV/TLC and RMS, strongest with MIFR (r=0.76 p<0.01). They concluded that obese subjects without overt obstructive airway disease have more severe lung dysfunction the marker of which is low MVV.

Courteix et al. (1997) analysed the effect of 1 year of intensive
swimming training on lung volumes, airway resistance and on the flow-volume relationship in per-pubertal girls. They compared five girls (9.3(0.5) yrs old) performing vigorous swimming training for 12 h a week with control group of 2 girls (same age) who participated in various sport activities of 2h per week. They include the parameters static lung volume maximal expiratory flows at 75%, 50, 25% of vital capacity, 1-s forced expiratory volume, airway resistance for comparison. They found that all parameters were in normal range for children of the same age. After 1 year of the training they found that vital capacity, total lung capacity, FRC were larger in girl swimmers than in control group. Parameter like height and weight were same. They also found that in girl swimmers FEVI.0, MEF25, MEF50(P<0.05), MEF75 and ratio of MEF50/TLC were increased. R(aw) was decreased in girl swimmers and increased in control group. They concluded that intensive swimming training pre-puberty enhances static and dynamic lung volumes and improves the conductive properties of both large and small airways. They speculated that at prepuberty intensive swimming training promotes isotropic lung growth by harmonizing the development of the airways and of alveolar lung spaces.

Doherty M et al. (1997) compared volumes in a large cross sectional sample of Greek swimmers and based athletes and sedentary controls. They measured forced vital capacity, forced expiratory volume in one second, peak expiratory flow, body mass and stature using standardised anthropometric techniques. They found that male and female swimming groups has larger (FEVI.0) than both land based athletes and sedentary controls (one way analysis of variance, P<0.001), in addition male national standard swimmers (n=38) had superior (FEVI.0) in comparison with male non-national standard swimmers (n=24, t test, P<0.05). Further logarithmic calculations showed than FEVI was highly related to in stature in males and females(r=0.93 and 0.86 respectively, P<0.001). They also
found resulting power functions, FEVI.o/stature were 0.64(0.18) litres/m² 2.69 and 0.33(0.24) litre/m².32 for males and females respectively. They concluded that swimmers has superior FEVI independent of stature and age in comparison with both land based athletes and sedentary controls, Male national standard swimmers also had superior FEVI independent of stature and age. They suggested that at earlier age at which training begins have significant influence on subsequent FEVI and swimming performances.

Lakhera SC et al. (1997) studied lung functions in contemporary healthy Indian female athletes of Ladakhi, Delhi, Vanvasi and Siddi origin for running events of Varying distances. They compared the lung function in female’s belongings to these four groups and examined lung function in relation to ethnic and environmental factors. They recorded vital capacity(VC) forced vital capacity(FVC), forced expiratory volume in one second( FEVI), expiratory reserve volume(ERV) and inspiratory capacity (IC) using conventional closed circuit spirometry. They estimated maximum voluntary ventilation (MMV) by collecting expired air during deep and rapid breathing in a 100 litres meteorological balloon for a period of 15 seconds and measured its volume. They found that Ladakhi females have higher VC, FVC, FEVI values than their counterparts, the average of MMV of Ladakhi females was significantly higher than Siddi females(P<0.05). They also observed that there was no significance different in MMV amongst Delhi, Siddi and Vanvasi young females.

Mehrotra PK et al. (1997) studied the pulmonary functions of young swimmers of K.D. Singh Babu Stadium Lucknow including 20 swimmers of age 15-20 years and 15 students as controls. They used the parameters FVC (forced vital capacity), FEVI (Forced expiratory volume) and Peak Expiratory Flow rate (PEFR). They recorded two readings one before the start and other at the end of practice season. They compared these readings with each other at the end of practice
season. They compared these readings with each other and also with values of the controls. They found that FVC, FEVI, PEFR raised significantly in swimmers after swimming session so their results indicates that swimming has considerable effect on enhancing lung functions of an individual. They suggested including swimming in exercise programme for rehabilitation of respiratory patients having compromised lung functions.

Suzuki M et al. (1997) studied age related changes in static maximal inspiratory and expiratory pressure. They evaluated 240 subjects of age 20-91 without cardiopulmonary, endocrine or neuromuscular diseases. They found PLmax and PEmax declined with advancing age. PLmax and PEmax both are correlated with grip strength, VC , TLC, FEVI , height and weight. They found that grip strength was an independent predictor for PLmax and PEmax , but age is not an independent predictor. They revealed that static maximal respiratory pressure decreases with aging. Age dependent changes in respiratory muscle function depends on other factors like lung volume, skeletal muscle status and body composition.

Hautmann H et al. (2000) prospectively used a representative sample of 504 healthy volunteers (248 males and 256 females) between 18 and 82 yrs of age with normal lung function. They recorded age, height, weight, body mass index (BMI) smoking status and incorporated stepwise in multiple regression analysis to determine prediction equations. They defined the lower limits of normal range as fifth percentile of residuals derived from regression model. They found significant correlation with height, weight, BMI,FEVI, PEF and FVC and strongest correlation with sex and age (P<0.001). They recorded mean values of Pimax 9.95 k Pa for men and 7.43 k Pa for women. They suggested that smoking status and smoked pack years were not independent predictors of inspiratory pressures. They recorded lower limits of normal range 59% for women
and 60% for men of predicted Pimax. They concluded that normal values should represent the lower limit of the normal range derived from regression model. They recommended prediction equations as well as lower limits of normal to be used by pulmonary function laboratories in young and old patients.

Baydur A et al. (2001) found relationship among respiratory muscle strength, lung volumes and degree of dyspnea in patients with sarcoidosis. They measured lung volumes and maximal respiratory muscle strength in 36 patients with sarcoidosis and 25 control subjects free of cardio respiratory disease. They used activity tolerance assessment scale ranging from rest to climbing hills or stairs in sarcoidosis patients to find degree of dyspnea. They found all the values less than control values such as Mean FVC, maximal voluntary ventilation, TLC, FRC, Residual volume, DLCO were all 16% less (in all cases p less than 0.001), Pimax, Pemax were 37% and 39% less than control values (both at p<0.01). They also found that Pimax and Pemax decreases with increasing dyspnea in a more graded, steady manner than spirometric and DLCO values. They observed strong inverse relationships between Pemax and Pimax with dyspnea level (p<0.01 and p<0.01 respectively). They found correlation between Pimax and Pemax with absolute values of FVC but only Pemax correlated with residual volume and percent predicted values of TLC. They concluded that maximal respiratory pressure correlate more closely with dyspnea level than lung volumes and DLCO, respiratory pressure may be more reliable index of functional work capacity and reflection of activities of daily living than standard tests of lung function.

Eastwood PR et al. (2001) determined whether whole body endurance whether whole body endurance training is associated with increased respiratory muscle strength and endurance. They used six marathon runners and six sedentary subjects to measure respiratory
muscle strength and endurance. They found that PI max was similar between two groups but maximum threshold pressure was greater in marathon runners (90+/8 vs. 78+/-10% of PI max respectively mean +/-SD, P<0.05), efficiency of the respiratory muscles was also similar in both groups being 2.0+/-1.7% and 2.3+/-1.8%. They also found being higher tidal volume longer that marathon runners breathed with low frequency inspiratory and expiratory time during progressive threshold loading. At maximum threshold pressure; marathon runners had low arterial O² saturation but perceived effort was maximal in both groups. They also found that apparent increase in respiratory muscle endurance of athletes was because of difference in breathing pattern adopted during loaded breathing rather than respiratory muscle strength. They concluded that sensory rather than respiratory muscle conditioning may be an important mechanism for increasing whole body endurance.

Kesavachandran C et al. (2001) studied alteration of lung volumes in swimmers performing different stokers, due to lack of knowledge regarding lung volumes of different strikers. The energy expenditure, O₂ consumption rate, body movements like arm and leg movements different with each stroke so swimmers lung function status and mechanics of breathing has to cope up with stroke techniques. They found that lung volumes VIZ, VC, FVC, FEVI decreases from resting condition to after swimming performance in free style and butterfly stroke swimmers due to fatigue of respiratory muscle. They observed higher lung volumes in swimmers (performing different strokes) on comparison with age and height matched controls, because of higher breath holding ability which facilitates the increase in strength of respiratory musculature. They concluded that lung volumes are influenced by different swimming strokes as lung volumes different with respect to stroke used by swimmer.
Kubiak - Janczareek E et al. (2005) studied the influence of swim training on the function of the respiratory system in girls and boys aged 10-18 years with a total of 1625 spirometries. They measured vital capacity, airflow airway during expiratory and inspiration, maximum voluntary ventilation (MVV). They interpreted the result on basic of comparative analysis of age and height matched groups of girls/boys swimmer and sedentary controls. They investigated the effect of swim training on spirometric parameters with the regards to anthropometric characteristic with the neural networks method. They found that FVCEX and FEVI were correlated with the height, arm span and dimensions of the thorax, while airflow in airway during expiration was unaffected by swimming. They also observed that swimmers who were trained regularly for 7-8 years have significantly higher inspiratory airflows, due to effect of training on inspiratory muscles. They concluded that vital capacity and airflow condition in airways during expirations are not influenced by swim training.

Sylvester KP et al. (2005) studied lung volumes in healthy Afe-Caribbean children of age 4-17 yrs and tried to compare these with predicted Caucasians reference values. They assessed 80 AC children with a median age of 9 (range 4.3-17.8) yrs. They measured standing and sitting height, TLC (pleth), FRC (pleth), VC (pleth), helium gas dilution FRC (He), Spirometry FEVI and FVC. They found significant correlation in lung volumes of AC with standing height and significant difference from values predicted from Caucasians reference values based on standing height (P<0.05). They also found significant difference in TLC (pleth), FRC (pleth), FRC (He), RV (pleth), VC (pleth), FEVI and FVC in relation to sitting height or 90% or 77% of values predicted from Caucasians reference values based on height(P<0.05).
Thorson E et al. (2006) studied the post exercise reduction in diffusing capacity of the lung after moderate intensity running and swimming. They used six trained swimmers and six trained runners who never dived. They subjects performed 30 min moderate intensity 75% of their maximal heart rate. They measured lung function including a flow volume loop and TI (CO) (reduction in transfer factor of lung for carbon monoxide) 30 min before and 60-90 minutes after exercise. They found that there were no significant changes in dynamic lung volumes or maximal expiratory flow rates but TI (CO) decreased 4.5 (S.D. = 4.8) and 4.7 (SD = 4.6) % after swimming and running respectively (P<0.01). They found no difference in the response between runners and swimmers; in fact the response was not associated with lung size. They concluded that even moderate exercise preceding measurements of TI (CO) contribute significantly to lung function changes immediately after open sea dives.

Basu CK et al. (2007) studies the changes in pulmonary function of human male volunteers from 2 different populations- Indians and Kyrgyzis before and after ascent to 3200 cm. and during a 4 week stay at that attitude. The subjects of this study were ten healthy soldiers of Indian Army (22-25 years) and 10 Kyrgyzis (19-20 years) whose height and weight were matched. They evaluated their pulmonary functions at baseline (Bishhek 760m) on day 2, 13 and 25 at a mountain clinic at Tuya Ashuu Pass (3200m) in the northern Tien Shan Range and in return to Bishkek. They used dry spirometer to measure lung function at each location. They included that Kyrgyzis had significantly largely forced vital capacity(FVC), forced expiratory volume in 1 Second (FEV(1)) than Indians but they have comparable peak expiratory flow rate (PEFR), forced expiratory flow rate at 29 to 75% of FVC (FEF 25-75%) and maximal voluntary ventilation (MVV). They also found that at high attitude (HA), FVC showed significant reduction on day 2 in Kyrgyzis, but in Indians FVC showed gradual reduction and on day 25, it was significantly reduced as compared
with baseline value. They notice no change in FEVI with altitude in both groups volumes and inspiratory muscle strength decline due to participation in triathlon.

Mickleborough TD et al. (2008) studied the anomalous respiratory characteristics of competitive swimmers. They assessed inspiratory muscle work, the respiratory muscle and pulmonary function of 30 competitively trained swimmers at the beginning and end of an intensive 12 week swim training (ST) program. They used swimmers (n=10) combined ST with either inspiratory muscle training (IMT) set at 80% sustained maximal inspiratory pressure (SMIP) with progressively increased work rest ratios until task failures for 3 days per week (ST +IMT) or ST with Sham-IMT (ST+SHAM-IMT, n =10) or acted as controls (ST only, ST, n=10). They measured respiratory and pulmonary function at the beginning and end of 12 weeks study period. They found that there was no significant difference (P > 0.005) in respiratory and pulmonary function between groups (ST + IMT, ST + SHAM- IMT and ST) at baseline and at end of week study period. They also observed that maximal inspiratory and expiratory volume in 1-s, total lung capacity, diffusion capacity of the lung.

Rong C et al. (2008) investigated pulmonary function and cytokine level in professional athletes to explore the impact of various sports on respiratory system function and to evaluate the possible role of systemic anaphylaxis. For this purpose, athletes were recruited from 10 different sports including swimming, water ballet, shooting, volley ball, softball, football, kickboxing, fencing, judo and track and field. They measured forced vital capacity, forced expiratory volume in one second FEVI, vital capacity (VC), peak expiratory flow PEF, maximal mid expiratory flow curve MMEF, forced expiratory flow rate FEF (25-75%). They also recorded the medical history of all athletes. They analyzed correlation between lung function measurements and the different sports, age, gender, height, weight. In some athletes,
serum was sampled to detect 1L-4 and 1L-10 concentrations. They also analyzed correlation between pulmonary function and cytokine levels in these subjects. They ducted allergic rhinitis and asthma only in swimmers with an incidence of 56.52% (13/23) and 8.70% (2/23) respectively. There was significant correlation between lung function measures with sports, age, gender, height and weight. They also found that male athletes have superior ventilation function (including FVC, FEV(1), FEVI/FVC and MMV) than females and swimmers have superior ventilation functions than others. They concluded that lung function measurements in various athletes were correlated with sport, age, gender, height and weight, the lung capacity of swimmers was greater than other athletes. They observed small airway dysfunction in some swimmers and endurance athletes. They also observed an association between systemic anaphylaxis and small airway dysfunctions after prolonged regular training particularly following swimming and endurance training.

Guenette JA et al. (2009) determined factors which contribute to the higher total work of breathing (WOB) during exercise in women. They performed a comprehensive analysis of 16 endurance trained subjects (8 men and 8 women) that underwent a progressive cycle exercise test to exhaustion. They were continuously monitored the esophageal pressure, lung volumes, ventilatory parameters throughout exercise. They used modified Campbell diagrams to partitions the esophageal-pressure volume data into inspiratory and expiratory resistive and elastic capacity. They did not correlate the decrease of respiratory mouth pressure to the decrease of lung volumes. They also found significant reduction of maximal expiratory pressure in adult onset GH deficient patients as compared to healthy subjects (P<0.05). They record no significant difference in any of evaluated parameters after 6 months. They found that inspiratory
resistive WOB at 50, 75 and 100 l/min was 67, 89, 109% higher in women respectively \( p < 0.05 \), the expiratory resistive WOB was 131% higher in women at 75 l/min \( p < 0.05 \) with no differences at 50 or 100 l/min. They record no significant sex differences in inspiratory or expiratory elastic WOB across any absolute minute ventilation. They also found that total WOB was 120, 60, 50, 45% higher in men at 25, 50, 75 and 100% of maximal exercise ventilation respectively \( p < 0.05 \) because of large part to their much higher tidal volumes and thus higher inspiratory elastic WOB. When standardized for a given work rate to body mass ratio they observed that total WOB was significantly higher in women at 3.5w/kg (239+/+-31 vs 173+/+-12J/min, \( P < 0.05 \)) and 4w/kg (387+/53 vs 243+/+-36J/min, \( P < 0.05 \)) because of significantly higher inspiratory and expiratory resistive WOB. They concluded that higher total WOB in women at absolute ventilation and for given work rate to body mass ratio is due to substantially higher resistive WOB which is due to smaller female airways relative to males and a breathing pattern that favours a higher breathing frequency.

Clin D et al. (2009) they aimed to evaluate the airway response to a methacholine challenges, a cucapnic voluntary hyperpnoea (EVH) test, a field based exercise test (FBT). And a laboratory based exercise test (LBT) in adult elite swimmers. They investigated airway responsiveness and airway inflammation in adolescent elite swimmers. They also evaluated the acute effects of a training session in an indoor swimming pool or airway inflammation in adolescent elite swimmers. They studies two groups’ adult elite and adolescent elite swimmers. They examined the airway response in four airway provocation tests; methacholine challenges, EVH test, FBI and LBT in adult elite swimmers \( n = 16 \), Airway responsiveness to EVH and methacholine and airways inflammation in adolescent elite swimmers \( n = 33 \) and compared the findings with those in asthmatic adolescents \( n = 32 \) and unselected adolescents \( n = 35 \). Further they examined the
acute effect of swimming in airway inflammation in a subpopulation of adolescent swimmers (n=21). They evaluated airway inflammation by using sputum induction, exhaled nitric oxide (FeNO) and exhaled breathe condensate (EBC). They reported that swimmer did not differ from that in unselected adolescents nor did the adolescent’s swimmer have signs of airway inflammation. They reported that there was no acute effect of a swimming training session in an indoor chlorinated pool on lung function or airway composition in adolescent swimmers. They concluded that elite swimming result in airway changes with AHR and airway inflammation.

Ondolo C. et al. (2009) evaluated the nasal, bronchial functions, before and after swimming and the relationship between nasal resistances and FEVI in competitive swimmers. They examined a group of 30 competitive swimmers. They used a specific questionnaire from both competitive swimmers and the 150 visitors of a swimming pool. They also carried out spirometry and respiratory test of the swimmers before and training session. They found that 18% of the population reported nasal sensual symptoms after swimming. They observed that variations in FEVI and differedence between nasal volumes and resistance before after and after swimming were not statistically significant. They also found that nasal patency increased or remained unchanged in 21/30 athletes. They concluded that swimming is able to increase nasal patency or to leave it unchanged. They observed temporary worsening of the nasal patency in only a few hyper reactive patients; no variations at bronchial level were found in whole group. Swimmer when the age, height, training duration of the swimmers performing different strokes was almost matched. The results can be used for selection trails of swimmers.

Alves A et al. (2010) assessed the nasal response to exercise in competitive runners. They measured nasal symptoms, peak nasal inspiratory flow, lung function, dyspnea and airway inflammation
before and after training session of 19 international-level swimmers and 13 professional runners. They also measured exercise induced rhinitis (fall in peak nasal inspiratory flow above 20% from baseline and adopy by positivity to skin prick testing). They compared the changed within groups using paired t-test and differences by analysis of covariance. They found that exercise induced rhinitis was similar between the swimmers induced rhinitis was similar between swimmers and runners 21% and 23%, but swimmers experienced decrease in nasal inspiratory flow levels and increase in sneezing, nasal congestion, itching and postnasal drip after exercise. They observed that differences in changes was only significant for postnasal drip (P=0.050). The exercise induced rhinitis experienced by all subjects was non-atopic. They observed an overall improvement in nasal flows, sneezing, itching after the exercise in atopic athletes and no significant differences in changes between atopic and no atopic

Nualnim N et al. (2011) studied the influence of regular swimming on vascular disease risks. They performed measurements of vascular function in middle aged and older swimmers, runners and sedentary controls. There were no group differences in age, height, dietary intake, fasting plasma concentrations of glucose, total cholesterol and low density lipoprotein volume. Further, runners and swimmers were not different in their weekly training volume. They found that Brachial systolic blood and pulse pressure were higher (p<0.05) in swimmers than in sedentary controls and runners. They also observed that carotid systolic blood pressure and carotid pulse pressure were lower (p<0.05) in runners and swimmers than in sedentary controls. Further, carotid arterial compliance was higher (p<0.05) and β-stiffness index was lower (p<0.05) in runners and swimmers than in sedentary. They also found that cardiovagal baroreflex sensitivity (p<0.05) was greater in runners than in sedentary controls and swimmers, baroreflex sensitivity (p=0.07), brachial artery flow mediated dilation was significantly greater.
Sable M et al. (2012) studied and compared the pulmonary function tests of two different groups of athletes, swimmers and runners. They compared thirty regular swimmers with thirty middle distance runners with age, sex height and weight. They found swimmers have higher Tindal Volume (TV), forced vital capacity (FVC), and forced expiratory volume in one second (FEVI) and maximum voluntary ventilation (MVV) than runners. They concluded that swimming exercise affects lung volume measurements because respiratory muscles including diaphragm are used to develop greater pressure which results in functional improvement of these muscles, alterations in elasticity of lung and chest wall, ventilator muscles and ultimately results in improvement of forced vital capacity other lung functions of swimmers than runners.

Silvatti AP et al. (2012) studied which differences long term swimming training can cause on trunk mechanics during breathing and how these differences are related to the years of swimming training. They used video plethysmography for data equation are preprocessing. They compared a group of swimmers (who followed a long term intensive swimming training) with non-swimmers control group. The participants of both groups performed quiet breathing and vital capacity tests. In order to analyses the relative partial volume variation and the co-ordination among trunk compartments involved in respiration, they calculated the relative amplitude and cross correlation among volumetric time varying signals which were obtained from the compartmental volumes associated with each breathing curve. On the basis of results of mixed ANOVA test (p<0.05) they revealed higher coefficient of variation (P<0.01) and correlation among trunk compartments in the swimmers group when vital capacity was performed. They found significant linear regression between the years of swim training and the coefficients of variation and correlation. They suggested that after long periods of intensive swim training, athletes develop specific breathing patterns featuring
higher volume variations in the abdominal region and more coordination among compartments involved in forced respiratory tasks such as vital capacity.

Silvestri M et al. (2013) studied the pulmonary function and airway responsiveness in young competitive swimmers. They investigated whether lung volumes increase with duration of swimming training, related to an obstructive abnormality associated with airway hyper responsiveness and asthma like symptoms. They measured forced expiratory volume in sec (FEVI), forced vital capacity (FVC), airway responsiveness and skin prick test in 34 children/adolescents of age 7-19 years who are trained for competitive swimming. Moreover, their life time exposure, i.e. the hours spent in pool was strongly correlated with their age at the time of study. They estimated the effect of swimming activity from the relationship between lungs and its function date and age. They found positive correlation between FVC Z-Score and age(indicating that absolute values increased more than expected with normal growth), negative correlation between FEVI/FVC and age. They also observed the most of the subjects had allergic sensitization to aeroallergens and having asthma like symptoms and/or airway hyper responsiveness but these conditions does not alter the relationship between lung function.

Myrianthefs P & Baltopoulos G (2013) examined whether professional athletes may require higher tidal volume (TV) during mechanical ventilation hypothesizing that they have significantly higher "normal" lung volumes compared to what was predicted and to non-athletes. By using Spiro SP-1 spirometer (Schiller, Switzerland) Measured and predicted spirometry values of athlete and non-athlete. Normal TV (6 mL/kg of predicted body weight) was calculated as a percentage of measured and predicted forced vital capacity (FVC) and the difference (δ) was used to calculate the additional TV required using the equation: New TV (TVN) = TV + (TV × δ). Professional
athletes having higher FVC compared to non-athletes which was predicted (by 9% in females and 10% in males). High performance females athletes may require ATV of 6.6 mL/kg for males and 6.5 mL/kg respectively. Non-athletes may require a TV of 5.8 ± 0.1 mL/kg and 6.3 ± 0.1 mL/kg for males and females. Their research show that athletes may require additional TV of 10% (0.6/6 mL/kg) for males and 8.3% (0.5/6 mL/kg) for females during general anesthesia and critical care which needs to be further investigated and tested.

Peric M et al. (2014) examined the applicability of sport-specific fitness tests (SSTs), anthropometrics, and respiratory parameters in predicting competitive results among pubescent synchronized swimmers. For this study 25 synchronized swimmers (16-17 years; 166.2 ± 5.4 cm; and 58.4 ± 4.3 kg) volunteered selected. The independent variables were body mass, body height, Body Mass Index (BMI), body fat percentage (BF%), lean body mass percentage, respiratory variables, and four SSTs (two specific power tests plus one aerobic- and one anaerobic-endurance test). Competitive achievement in the solo figure competition dependent variables were selected. The reliability analyses, Pearson's correlation coefficient and forward stepwise regression were calculated. For pubescent synchronized swimmers SSTs fitness states testing were reliable. The forward stepwise regression retained two SSTs, BF% and forced vital capacity (FVC, relative for age and stature) in a set of predictors of competitive achievement. Beta coefficients are found for aerobic-endurance, SST and FVC significant. The sport-specific measure of aerobic endurance and FVC appropriately foretold competitive achievement with regard to the figures used in the competition when competitive results (the dependent variable) were obtained. This study suggests Athletes and coaches should be aware of the probable negative influence of very low body fat levels on competitive achievement.
Tanner DA et al. (2014) examined the effect of exercise mode on ventilator patterns, for two maximal graded exercise tests; one running on a treadmill and one cycling on an ergometer. 22 trained men were selected. Tidal flow-volume (FV) loops were recorded during each minute of exercise with maximal loops measured pre and post exercise. Long distance runners having greater VO2 peak than cycling (62.7±7.6 vs. 58.1±7.2mLkg(-1)min(-1)). Ventilator equivalents for O2 and CO2 were significantly larger during maximal cycling, although maximal ventilation (VE) has no differ between modes. During maximal cycling ventilator equivalents for O2 and CO2 were significantly larger. Arterial oxygen saturation (estimated via ear oximeter) was also greater during maximal cycling, as were end-expiratory (EELV; 3.40±0.54 vs. 3.21±0.55L) and end-inspiratory lung volumes, (EILV; 6.24±0.88 vs. 5.90±0.74L). Based on these results they conclude that ventilatory patterns differ as a function of exercise mode and these observed differences are likely due to the differences in posture adopted during exercise in these modes.

Tikhonov VF & Agafonkina TV (2014) examined the breathing pattern characteristic of kettlebell athlete’s mainly breathing frequency (f), tidal volume (VT), minute ventilation (VE). They also researched these parameters using the weight of kettle bells and skill dependent on athletes. For qualitative and quantitative evaluation of the main indicators of kettle bell athletes breathing patterns they used Spirograph SMP-21/01-“R-D”.changes were found in breathing of athletes of master of sports (MS) and candidate master of sports (CMS) during exercise on two parameters- frequency of breathing and tidal volume. They found out while the weight of the kettle bell increases the breathing frequency increases and tidal volume decreases. Dominated changing in tidal volume of International Masters of Sports (MSIC) athletes increases from 0.7 +/- 0.11 to 1.2 +/- 0.11 (p < 001). In MSIC athletes tidal volume is approximately to level of 1.2 +/- 0.1, which invariably leads to an increase in breathing
frequency. With the transition forms of breathing in competition exercises discovered Kettle bell sports. High performance level of athletes is related to undergoing breathing regulation, trying constantly to keep same level of gas composition in functional residual capacity (FRC) at a time of performing competition exercises. This research determines the importance of improving breathing patterns for Kettle bell athletes if they want to improve performance.

Durmic T et al. (2015) studied Sport-specific influences on respiratory patterns in elite athletes. Their objective is to examine differences in lung function among sports that are of a similar nature and to determine which anthropometric/demographic characteristics correlate with lung volumes and flows. For this they used elite athletes of all ages and sports. They found that across all age groups and sport types, the elite athletes showed spirometric values that were significantly higher than the reference values. They also found that the values for FVC, FEV1, vital capacity, and maximal voluntary ventilation were higher in water polo players than in players of the other sports evaluated (p < 0.001). In addition to this they also observed that PEF was significantly higher in basketball players than in handball players (p < 0.001) Most anthropometric/demographic parameters correlated significantly with the spirometric parameters evaluated. They noticed that BMI correlated positively with all of the spirometric parameters evaluated (p < 0.001), the strongest of those correlations being between BMI and maximal voluntary ventilation (r = 0.46; p < 0.001). Furthermore the percentage of body fat correlated negatively with all of the spirometric parameters evaluated, correlating most significantly with FEV1 (r = -0.386; p < 0.001). On the basis of their studies they concluded that the type of sport played has a significant impact on the physiological adaptation of the respiratory system. That knowledge is particularly important when athletes present with respiratory symptoms such as dyspnea, cough, and wheezing. Because sports medicine physicians use predicted
(reference) values for spirometric parameters, the risk that the severity of restrictive disease or airway obstruction will be underestimated might be greater for athletes.

Lazovic B et al. (2015) studied the differences in functional respiratory parameters in various types of sports by measuring lung volumes and to extend the existing factors as well as sport disciplines which affect respiratory function the most. For their studies they used a total of 1639 elite male athletes, aged 18-35 years. They divided them in 4 groups according to the predominant characteristics of training: skill, power, mixed and endurance athletes. They performed basic anthropometric measurements and spirometry. They compared the groups and performed Pearson simple correlation to test the relation between anthropometric and spirometric characteristics of athletes. Their findings are that all anthropometric characteristics significantly differed among groups and correlate with respiratory parameters. The highest correlation was found for body height and weight. They concluded that sports participation is associated with respiratory adaptation, and the extent of adaptation depends on type of activity. Endurance sports athletes have higher lung volumes in comparison with skill, mixed and power group of sport.

Lazovic-Popovic B et al. (2016) studied the influence of physical activity on the development of the respiratory system. They also found that Physical activity has a positive effect on the function of the whole human body system. For this they considered swimming as good exercise to affect respiratory system. Their aims was to determine pulmonary function and to correlate it with anthropometric features of sportsmen, represented by land- and the water-based elite athletes comparing with their sedentary counterparts and was to examine whether the training factors (frequency and amount) influence pulmonary function in swimmers, when controlled for anthropometric features. They matched 38 elite male swimmers for
age and sex with two hundred and seventy-one elite football players and one hundred controls who were not involved in any routine exercise. They recorded lung volumes by pulmonary function test and analyzed them statistically. They found that Swimmers had statistically higher values of VC, FVC, FEV1 and FEV1/FVC when compared to both the football players and the controls, as the latter two showed no in-between differences. They also found that there was significant positive correlation between age, body weight and body height and each of the above named pulmonary parameters, when presented separately for swimmers, football players and the control group. They also observed, larger lung volumes in swimmers were not influenced by training period, age at the beginning of training and weekly extent of personal training.

Moradians V et al. (2016) studied the effect of Eight-Week Aerobic, Resistive, and Interval Exercise Routines on Respiratory Parameters in Non-Athlete Women. The purpose of their study was to evaluate and compare the effects of eight-week aerobic, resistance, and interval exercise routines on respiratory parameters in non-athlete women. For this Thirty-six non-athlete women between 18-25 years old participated in prospective quasi-experimental trial. They divided the subjects in three groups(aerobic, resistance and interval exercise, 12 in each group). Each group exercised three times a week for a total of eight weeks (24 sessions in total). They recorded Pulmonary function tests (PFT), including tidal volume (VT), inspiratory reserve volume (IRV), expiratory reserve volume (ERV), inspiratory capacity (IC), vital capacity (VC), forced vital capacity (FVC), forced expiratory volume in the first seconds (FEV1), the ratio of FEV1/FVC, peak inspiratory flow (PIF), and forced expiratory flow (FEF 25-75%) before and after the implementation of the exercise program for all participants. They analyzed the data using paired t-test and one-way ANOVA. They found that the mean age of participants was 20.17 ± 2.13. Their results of the paired T-test indicated that VC
significantly increased in the group assigned to aerobic exercise ($P = 0.028$), while IC ($P = 0.012$) and PIF ($P = 0.019$) significantly increased in the group assigned to interval training. They concluded that interval and aerobic exercise routines could improve pulmonary functions and aerobic and interval training can be used to increase VC, IC, PIF, in non-athlete women.

Papp ME et al. (2016) studied the effects of yogic exercises on functional capacity, lung function and quality of life in participants with obstructive pulmonary disease. Their aim was to evaluate the effects and feasibility of hatha yoga (HY) compared to a conventional training program (CTP) on functional capacity, lung function and quality of life in patients with obstructive pulmonary diseases. They used thirty-six patients with obstructive pulmonary disease of Karolinska University Hospital, Stockholm, Sweden among outpatients. Forty patients were randomized with 36 (24 women, median age=64, age range: 40-84 yrs) participating in HY ($n=19$) or CTP ($n=17$). Both HY and CTP involved a 12-week program with a 6-month follow-up. They measured Functional capacity (using the 6-minute walk test, 6MWT), lung function (spirometry), respiratory muscle strength (respiratory pressure meter), oxygen saturation (SpO2), breathlessness (Borg), respiratory rate ($f$) and disease-specific quality of life (CRQ) at baseline, at 12 weeks and at a 6-month follow-up. They showed significant effects on the CRQ fatigue ($p=0.04$) and emotional ($p=0.02$) domains, with improvements in the CTP group after the 12-week intervention ($p=0.02$ and 0.01, respectively) but not in the HY group. They also found that within each group, significant improvements emerged for the 6MWD after 12-week intervention (HY: mean difference 32.6 m; CI 10.1-55.1, $p=0.014$; CTP: mean difference 42.4 m; CI 17.9-67.0, $p=0.006$). They also noticed improvements in CRQ in both groups. Within the HY group, the respiratory rate ($f$) decreased and SpO2 increased. Improved effects after follow-up emerged only for the CTP group for 6MWD ($p=0.04$), diastolic blood
pressure (p=0.05) and CRQ emotional domain (p=0.01). They concluded that after 12 weeks, 6MWD improved significantly within both groups. Within the HY group, improvements in the CRQ mastery domain, f and SpO2 emerged. Within the CTP group, there were improvements in lung function parameter forced vital capacity (FVC), respiratory muscle strength and all CRQ-domains. The CTP also exhibited effects on CRQ after the 6months follow-up.

Sales AT et al. (2016) reviewed Respiratory muscle endurance after training in athletes and non-athletes. Their objective is to evaluate the effects of respiratory muscle training (RMT) on respiratory muscle endurance (RME) and to determine the RME test that demonstrates the most consistent changes after RMT. They conducted the electronic searches in EMBASE, MEDLINE, COCHRANE CENTRAL, CINHAL and SPORT Discus, They used PEDRO scale for quality assessment and also performed meta-analysis to compare effect sizes of different RME tests. 20 subjects were used by them for their studies. Isocapnic hyperpnea training was performed in 40% of the studies. Meta-analysis showed that RMT improves RME in athletes (P = 0.0007) and non-athletes (P = 0.001). Subgroup analysis showed differences among tests; maximal sustainable ventilatory capacity (MSVC) and maximal sustainable threshold loading tests demonstrated significant improvement after RMT (P = 0.007; P = 0.003 respectively) compared to the maximal voluntary ventilation (MVV) (P = 0.11) in athletes whereas significant improvement after RMT was only shown by MSVC in non-athletes. The effect size of MSVC was greater compared to MVV in studies that performed both tests. The meta-analysis results provide evidence that RMT improves RME in athletes and non-athletes and MSVC test that examine endurance over several minutes are more sensitive to improvement after RMT.

Shin YS et al. (2016) studied the Differences in respirogram phase between taekwondo athletes and non-athletes. They took respiratory measurement using spirometry for 13 elite taekwondo
poomsae athletes. They found that in respirogram phasic analysis, the inspiratory area of forced vital capacity were significantly increased in the athletes than in the non-athletes. They also observed that the slopes of the forced vital capacity for athletes at slopes 1, 2, and 3 of the A area were significantly higher than those for the non-athletes. They also observed that in correlation analysis chest circumference was significantly correlated with slope 1 of the A area of the forced vital capacity. They indicated that the differences in respirogram phasic changes between athletes and non-athletes may contribute to better understanding of respiratory function.