SYSTEMATIC REVIEW

EFFECT OF RESISTANCE TRAINING ON RESPIRATORY PARAMETERS - A SYSTEMATIC REVIEW

ABSTRACT

BACKGROUND AND OBJECTIVES
Normally, aerobic exercises are considered as the therapeutic medium for improving cardiopulmonary parameters. The objective of this review is to evaluate the impact of aerobic resistance training on pulmonary parameters.

DATA SOURCES
Pubmed, Google Scholar, Science Direct, Biomed-Central (BMC), Pubmed-Europe, Medline, EMBASE and Pedro

ELIGIBILITY CRITERIA
Studies investigating role of resistive exercise training on pulmonary parameters including FVC, FEV1, VO_2, TLCO etc, either alone or in combination with other exercise regimes, are included.

REVIEW METHODS
Data was extracted according to a standardized assessment form according to inclusion criteria. Risk of bias was evaluated according to the Cochrane risk of bias guidelines and qualitative analysis was performed.

RESULTS
Out of 13 selected studies, 4 studies supported the view that resistive exercises have significant role in improving the pulmonary parameters. There was a low risk of bias found among the studies that were selected and included in the review.

CONCLUSION
The review concludes that there is a low evidence for resistive exercises in improving the pulmonary parameters. However, more researches are needed to be conducted on the subject in future.

KEYWORDS
Resistance Exercise, Resistive training, FEV1, FVC, spirometric values, respiration, pulmonary parameters, cardiopulmonary endurance

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INTRODUCTION

Aerobic and anaerobic physical activity is evident for having curative as well as preventive effects on cardiovascular and respiratory systems by enhancing respiratory parameters, aerobic strength and oxygen consumption[1-3]. Predominantly, aerobic exercise are opted for cardiopulmonary endurance consisting of long duration and short intensity, as recommended by American College of Sports Medicine (ACSM)[4,5]. Factually, the positive effects of aerobic exercise in intensifying respiratory strength, pulmonary ventilation, oxygen consumption, enhancing lungs volumes and capillary diameter; and more specifically, its role in improving respiratory indices like Force Vital Capacity (FVC), Force expiratory volume in one Second (FEV1) and maximal voluntary ventilation (MVV); have been establish by the evidence of existing literature[6-10].

Anaerobic or resistance exercise, due to have focus on muscular strength and endurance too, are becoming an essential component of pulmonary rehabilitation program[11,12]. However, sports like basketball, water polo and rowers have been suggested to be significant in improving functions of pulmonary system and athletes involved in these sports have demonstrated statistically improved vital capacity (VC), force vital capacity (FVC) and force expiratory volumes in one minute (FEV_1), comparing to those of sedentary but healthy individuals[13]. Despite of all these evidences suggest that strengthening of small and fat free muscles is proved to be beneficial for controlling dyspnea and enhancing functional capacity in patient with COPD[14].

Resistance training of respiratory muscles is thought to be beneficial in improving strength as well as pulmonary parameters[15]. Moreover, one multidisciplinary review identifies musculature of pelvic floor as an important contributor in respiration, which plays a crucial role in generating intra-abdominal pressure[16].

Although, one study strongly recommend the potential effect of resistance training on FEV1 even if it is not consider to be the direct significance of resistance training but probably due to the improvement in lung physiology and functions as a consequence of pulmonary rehabilitation. Resistance training is considered to be an important treatment intervention in patient with COPD as it has a strong effect in boosting muscular strength and ultimately optimizing functional status[17].
Moreover, it has been suggested in a research that effect of resistance training in lower extremity is more influential in increasing minute ventilation (VE), O2 uptake, and decreasing dyspnea as compared to aerobic exercise of upper and lower extremities[18].

Interestingly, a research conducted among the non-active healthy males in Iran evaluated the relationship of resistance training as well as high intensity interval training exercise regimes with respiratory indices and inflammatory markers and concluded that the FEV1, FVC and other spirometric ratios significantly increased in the experimental groups comparing to the control group that receive no exercise[19].

Furthermore, a study done in 2017 on heart failure patients that significantly proved the fact that effect of combined aerobic and resistance training plus non-invasive ventilation is more influential in controlling dyspnea and quality of life than combined aerobic and resistance training, 6 minute walk test, FEV1 and FVC showed no improvement when compared between these two groups[20].

Beside these, other regimes of exercise are also conducted to check their effects on respiratory parameters. Therefore, a research was conducted to find out the relationship between the pilates exercise and respiratory parameters in obese sedentary women[21].

The current systematic review is aimed to derive a qualitative analysis of the recent available studies inquiring whether resistive exercises improve the respiratory parameters or have no effects on them.

METHODOLOGY

Eligibility criteria and Information Sources
The systemic review was conducted in accordance with the guidelines provided by PRISMA (Preferred Reporting Items for Systemic Review and Meta-Analysis). An electronic search with related keywords was conducted on various databases including Cochrane, Pubmed, Google Scholar, Science Direct, Biomed-Central (BMC), Pubmed-Europe, Medline, EMBASE and PEdro.

Search of Articles
Strategies acquired for literature searching include MeSH-terms and keywords using Boolean logic such as Pulmonary Function Test, Respiratory Parameters AND Resistance training, Respiratory Muscle Training, EXERCISE THER. The literature search was customized for the articles published in the duration between 2013 -2018 without any specification of language. However, all full texted articles accessed, were either in English originally or English translated versions were included in the review.

Study Selection
Apparently, 46 articles were retrieved in all out of which 13 articles were selected according to the inclusion criteria. The researches investigating the effects of resistance training on respiratory parame-

ters such as Forced Vital Capacity (FVC), Forced Expiration volume in first second (FEV1), Vital Capacity (VC), Minute ventilation (MV), Maximal Voluntary Ventilation (MVV), Maximum Oxygen consumption (VO2max), Maximum Pulmonary Inspiration (PImax), Maximum Pulmonary Expiration (PEmax) and Transfer factor for carbon monoxide (TLCO), among the healthy as well as in diseased individuals, were included without gender segregation.

Study Charactersitics

The characteristics of the researches, included in the review, include 2 quasi-experimental studies while the remaining 11 were Randomized controlled trials (RCTs). 9 of these studies independently designated an experimental group for resistive exercises as intervention while remaining 4 reported to have applied resistive exercise training in combination with other exercise regimes as demonstrated in figure 1.

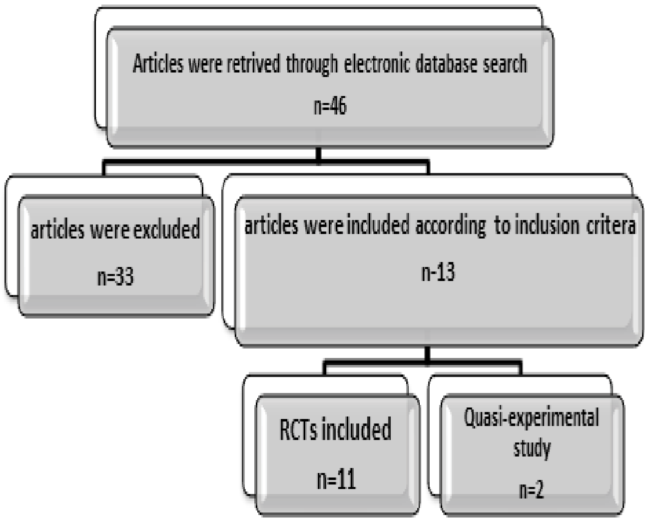


Figure: 1 Flow diagram representing study selection procedure and characteristics

Table 1: Represents the detailed list of included studies

S.no	Author	Year of Pub	Group	*n*	Intervention
1	Ganesh BR[22]	2018	Experimental	43	10 Lbs. sandbag breathing exercise for 5-10 minutes, thrice a week for 4 weeks
2	Molassiotis A[23]	2015	intevention	18	IMT sessions weekly for 12 weeks for a total of 30 mins/day
			control	18	
	Edvardsen E[24]	2014	training	30	high-intensity endurance and strength training (60 min, three times a week, 20 weeks)
4	Pothirat C[25]	2015	experimental	30	incremental strength and endurance with two 35-40-minute sessions per week for 8 weeks
5	Santana-Sosa E[26]	2013	training	10	Aerobic + strengthening Exercise, 3 day/week
			control	10	No intervention
6	Zambom-Ferraresi F[27]	2015	combined training	14	12 weeks, I d / week resistance &1d / week endurance training

			resistance training	14	12 weeks, 2 d / week resistance training
			control	8	No intervention
7	Rovedder PME[28]	2014	exercise	19	home based exercise; a combination of aerobic and strength training
			control	22	normal routine practices
8	Moradians V[29]	2016	aerobic	12	aerobic ex 40-60 min 3 / week (10 min WU, 20 min AA @70-80% MHR
			resistance	12	weight training 3 sets 10 reps of each ex, intensity increased by
			interval	12	Short periods of running at 85% maximum heart rate. Each session started with warm up, which was followed by five rounds of running 20, 30, 60, and 100 meters, and finished with cool down exercises.
9	Chun SP[30]	2015	experimental	15	Core stability exercises 30 min / session, 4 session / week for 8 weeks
			control	15	general exercises
10	Vonbank K[31]	2012	endurance training	12	cycle ergometer twice / week total duration 60 min intensity 60%
			progressive strength training	12	twice/ week 8-15 rep / set
			Combination	12	both combined
11	Tartibian[32]	2018	HIIT	12	n = 12, 30 min/day, 3 days/week at 60-90% of heart rate reserve for 8 weeks
			RT	12	n = 12, 60 min/day, 3 days/week by 60% - 90% of 1RM for 8 weeks
			NON-EX	12	No intervention
12	Maryam[33]	2013	Control	9	no intervention
			ET	9	(8 weeks, 3 sessions/week) for ET was 20-26 min/session running with 60-80% maximum heart rate (HR max
			RT	10	two circuits/session, 40-60s for each exercise with 60-80% one repetition maximum (1RM), 1 and 3 minutes active rest between exercises and circuits respectively

			ERT	9	in agreement with either ET or RT protocols, but the times of running and circuits were half of ET and RT
13	Aweto HA[34]	2015	A: aerobic	15	Aerobic exercise; treadmill, 10 min for 4week, 15min for 2 week, twice a for 6 week total
			B: resistance	15	Dumbbells, 50-70% of 1 RPM, 4 times in 20-30 sec, 12rep/set, 2times/week for 6week
			C: control	15	only counseling and educations, for 15 min/once/week

Data Extraction and Management

Data was extracted and quality was assessed in accordance with inclusion and exclusion criteria considering standardized protocols. A standardized assessment form was constructed in order to maintain validity and accuracy of data, extracted from the research articles. Furthermore, information was included as the name of the first author, year of publication, targeted population, sample size and its distribution in groups; and type of exercise regime as intervention as represented in table 1.

RESULTS

Selection of studies included

Originally, 46 research articles were extracted though an electronic search on various databases like Cochrane, Pubmed, Google Scholar, Science Direct, Biomed-Central (BMC), Pubmed-Europe, Medline, EMBASE and PEdro. All of these researches were published between 2013 and 2018. However, 13 studies were selected including 2 quasi-experimental and 11 randomized controlled trials after screening. Data was extracted and quality assessment was conducted in accordance with the standardized protocols. Meta-analysis and publication bias evaluation could not be performed due heterogeneity in outcome measures of the studies included in the systemic review.

Synthesis of Results

Outcome measures were assessed for each study along with the interventions applied to each study group in order to investigate the impact of resistance exercise training on respiratory parameters. Out of total 13 researches, included in the systematic review, 4 studies demonstrated significant impact of resistance training on respiratory parameters such as FEV1, FVC, FEV1/FVC ratio, POuptake, TLCO and MVV. However, the remaining 9 researches revealed non-significant outcomes for the intervention. Furthermore, among the 4 studies showing significant result, 2 of them indicated significant positive changes in POuptake, TLCO and VO2 only, while insignificant for FEV1, FVC, FEV1/FVC ratio. The remaining 2 studies supported the efficacy of resistance training in improving spirometric parameters, specifically FEV1, FVC and FEV1/FVC ratio, as illustrated in table 2.

Risk of Bias and overall study quality

The risk of Bias and study quality was assessed according to standard checklist as represented in table 3 and diagrammatically in figure 2

Selection Bias

Random Sequence Generation

Random sequence generation for 11 studies (Tartibian, 2018, Moradians V, 2016, Molassiotis A, 2015, Zambom-Farraresi, 2015, Edvardsen, 2014, Roveder PME, 2014, Sanatana-Sosa, 2013, Maryam, 2013, Vonbank K, 2012 and Aweto AH, 2015) demonstrated low risk of bias. However, 2 studies (Ganesh BR, 2018 and Chun SP, 2015) showed unknown and only one (Pothriat C, 2015) indicated a high risk of bias.

Allocation concealment

Allocation Concealment for 11 studies (Tartibian, 2018, Moradians V, 2016, Molassiotis A, 2015, Zambom-Farraresi, 2015, Edvardsen, 2014, Roveder PME, 2014, Sanatana-Sosa, 2013, Maryam, 2013, Vonbank K, 2012 and Aweto AH, 2015) demonstrated low risk of bias. However, 2 studies (Ganesh BR, 2018 and Chun SP, 2015) showed unknown and only one (Pothriat C, 2015) indicated a high risk of bias.

Performance Bias

Blinding of participants and personnel

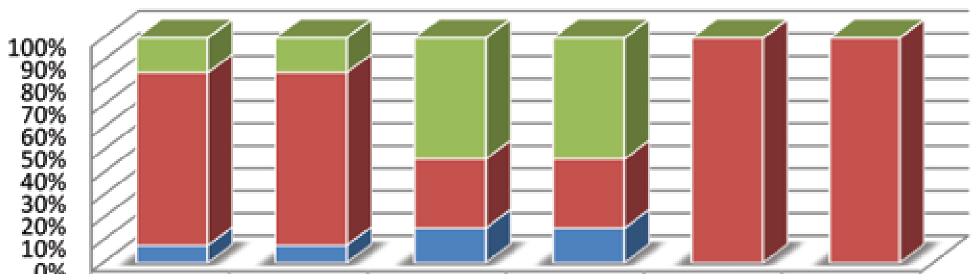
Blinding of participant and personnel was performed by 4 studies (Tartibian, 2018, Zambom-Farraresi, 2015, Edvardsen, 2014, Roveder PME, 2014) and demonstrated low risk of bias. Conversely, 7 studies (Ganesh BR, 2018, Moradians V, 2016, Chun SP, 2015, Pothriat C,2015, Maryam, 2013, Vonbank K, 2012, and Aweto HA, 2015) showed unknown and 2 studies (Molassiotis A, 2015 and Sanatana-Sosa, 2013) indicated a high risk of bias.

Table 2: Details of the outcomes of researches included in systemic review					
S.no	Author	Group	n	Intervention	Outcomes
1	Ganesh BR	Experimental	43	10 Lbs sandbag breathing exercise for 5-10 minutes, thrice a week for 4 weeks	FEV1, FVC,FEV1/FVC and lumbar stability improved
2	Molassiotis A	intevention	18	IMT sessions weekly for 12 weeks for a total of 30 mins/day	No obvious physiological changes in their FEV1 or FVC levels.
		control	18		
3	Edvardsen E	training	30	high-intensity endurance and strength training (60 min, three times a week, 20 weeks)	significant results for PO Uptake and , Tlco, non-significant for FEV1 , MVV
4	Pothirat C	Experimental	30	incremental strength and endurance with two 35-40-minute sessions per week for 8 weeks	No significant changes in lung function
5	Santana-Sosa E	training	10	Aerobic + strength training 3 day/week	Significant results in PImax &VO2 max and non-significant in FEV1 and FVC
		control	10	No intervention	
6	Zambom-Ferraresi F	combined training	14	12 weeks, I d / week resistance &1d / week endurance training	non- significant
		resistance training	14	12 weeks, 2 d / week resistance training	
7	Rovedder PME	exercise	19	home based exercise; a combination of aerobic and strength training	non-significant FEV1, FVC
		control	22	normal routine practices	
8	Moradians V	aerobic	12	aerobic ex 40-60 min 3 / week (10 min WU, 20 min AA @70-80% MHR	non-significant value for spirometric values
		resistance	12	weight training 3 sets 10 reps of each ex, intensity increased by	
		interval	12	Short periods of running at 85% maximum heart rate. Each session started with warm up, which was followed by five rounds of running 20, 30, 60, and 100 meters, and finished with cool down exercises.	

9	Chun SP	experimental	15	Core stability exercises 30 min / session, 4 session / week for 8 weeks	Significant increase in Pulmonary Function
		control	15	general exercises	
10	Vonbank K	endurance training	12	cycle ergometer twice / week total duration 60 min intensity 60%	Non-significant
		progressive strength training	12	twice/ week 8-15 rep / set	
		Combination	12	both combined	
11	Tartibian	HIIT	12	30 min/day, 3 days/week at 60-90% of heart rate reserve for 8 weeks	significant
		RT	12	60 min/day, 3 days/week by 60% - 90% of 1RM for 8 weeks	
		NON-EX	12	No intervention	
12	Khosravi M	Control	9	no intervention	
		ET (exercise training)	9	(8 weeks, 3 sessions/week) for ET was 20-26 min/session running with 60-80% maximum heart rate (HR max	non-Significant for FEV1/FVC
		RT (resistance training)	10	two circuits/session, 40-60s for each exercise with 60-80% one repetition maximum (1RM), 1 and 3 minutes active rest between exercises and circuits respectively	
		ERT	9	in agreement with either ET or RT protocols, but the times of running and circuits were half of ET and RT	
13	Aweto HA	A: aerobic	15	Aerobic exercise; treadmill, 10 min for 4week, 15min for 2 week, twice a for 6 week total	non-significant
		B: resistance	15	Dumbbell, 50-70% of 1 RPM, 4 times in 20-30 sec, 12rep/set, 2times/week for 6week	
		C: control	15	only counseling and educations, for 15 min/once/week	

Table 3:

Domains	Random Sequence Generation	Allocation Concealment	Blinding of Participants and Personnel	Blinding of Outcome Assessment	Incomplete Outcome Data	Selective Reporting
Ganesh BR, 2018	?	?	?	?	✔	✔
Tartibian, 2018	✔	✔	✔	✔	✔	✔
Moradians V, 2016	✔	✔	?	?	✔	✔
Chun SP, 2015	?	?	?	?	✔	✔
Molassiotis A, 2015	✔	✔	X	X	✔	✔
Pothirat C, 2015	X	X	?	?	✔	✔
Zambom-Ferraresi, 2015	✔	✔	✔	✔	✔	✔
Edvardsen, 2014	✔	✔	✔	X	✔	✔
Rvendder PME, 2014	✔	✔	✔	✔	✔	✔
Sanatana-Sosa, 2013	✔	✔	X	✔	✔	✔
Maryam, 2013	✔	✔	?	?	✔	✔
Vonbank K, 2012	✔	✔	?	?	✔	✔
Aweto HA, 2015	✔	✔	?	?	✔	✔



	Random Sequence Generation	Allocation Concealment	Blinding of Participant and personale	Blinding of outcome Asssessment	Incomplete Outcome Data	Selective Reporting
Unknown Risk	15.38	15.38	53.8	53.8	0	0
Low Risk	76.9	76.9	30.7	30.7	100	100
High Risk	7.69	7.69	15.38	15.38	0	0

Figure2: Authors perception for risk of bias

Detection Bias
Blinding of Outcome Assessment

Blinding of outcome Assessment was performed by 4 studies (Tartibian, 2018, Zambom-Farraresi, 2015, Sanatana-Sosa, 2013, performed by 4 studies (Tartibian, 2018, Zambom-Farraresi, 2015, Sanatana-Sosa,' 2013, Rovedder PME, 2014) and demonstrated low risk of bias. Conversely, 7 studies (Ganesh BR, 2018, Moradians V, 2016, Chun SP, 2015, Pothriat C, 2015, Maryam, 2013, Vonbank K, 2012, and Aweto HA, 2015) showed unknown and 2 studies (Molassiotis A, 2015 and Edvardsen, 2014) exhibited a high risk of bias.

Attrition Bias
Incomplete Outcome Data

None of the studies presented incomplete outcome data. All 13 studies (Tartibian, 2018, Zambom-Farraresi, 2015, Sanatana-Sosa, 2013, Rovedder PME, 2014, Ganesh BR, 2018, Moradians V, 2016, Chun SP, 2015, Pothriat C, 2015, Maryam, 2013, Vonbank K, 2012, and Aweto HA, 2015, Molassiotis A, 2015 and Edvardsen, 2014) indicated low risk of bias.

Reporting Bias
Selective Reporting

Selective reporting for all 13 studies (Tartibian, 2018, Zambom-Farraresi, 2015, Sanatana-Sosa, 2013, Rovedder PME, 2014, Ganesh BR, 2018, Moradians V, 2016, Chun SP, 2015, Pothriat C, 2015, Maryam, 2013, Vonbank K, 2012, and Aweto HA, 2015, Molassiotis A, 2015 and Edvardsen, 2014) indicated low risk of bias.

DISCUSSION

This systematic review has explored the impact of anaerobic resistance training exercise regime on various respiratory parameters including Forced Vital Capacity (FVC), Forced Expiration volume in first second (FEV1), Vital Capacity (VC), Minute ventilation (MV), Maximal Voluntary Ventilation (MVV), Maximum Oxygen consumption (VO2max), Maximum Pulmonary Inspiration (PImax), Maximum Pulmonary Expiration (PEmax) and Transfer factor for carbon monoxide (TLCO). However, meta-analysis could not be performed due to the heterogeneity of the outcome measures, interventions and targeted populations of the studies included in this systematic review.

The convergence of the findings of this systematic review revealed a low evidence of resistive exercise training regimes having a profound impact in improving respiratory parameters. Moreover, the studies demonstrating significant impact of resistance training on pulmonary system, also included those in which resistive training and aerobic were used in combination. Probably, the heterogeneous nature of target population of different researches included in the systematic review has stipulated the differences in result outcomes, since different pulmonary parameters respond distinctly to the same intervention.

Interestingly, a recently conducted meta-analysis, concluded with the effectiveness of exercise training (i.e. the combination of aerobic and anaerobic/ resistance exercise training) in improving the pulmonary function of individuals suffered with chronic obstructive pulmonary disease (COPD) [35]. In addition to this the study also deduced that exercise training has more profound effect alone than in combination with other regimes of treatment interventions[35]. The distinctive feature of this study was the systematic characterization of outcome measures that might be the reason of clear results.

Another systematic review and meta-analysis has deduced more specifically the positive impact of resistance exercise training in COPD patients. The review postulated results inquiring 7 outcomes including 2 primary and 5 secondary outcome measures. The prominent significant enhancement was demonstrated in FEV_1 with p-value of 0.04 and annulled the possibility of adversity in including resistance training in pulmonary rehabilitation regime[36].

Another challenging concept has been discussed in a research study that if there is a significant difference in the effects of high and low intensity upper and lower limb extension exercise considering various cardiovascular outcome measures like minute ventilation (MV), Oxygen Uptake (VO2 peak) and heart rate (HR). Subsequently, it revealed the absence of any relationship between intensity of exercise and acute cardiorespiratory changes in COPD patients. However, it does not discussed long-term effects for this intervention[37]. Meanwhile another study studied the impact of number and position of limbs engaged in the short bout resistive exercise on similar pulmonary parameters including FEV1, MV, VO_{2peak} and saturation of oxygen and concluded no significant impact of number of limbs engaged in exercise[38].

CONCLUSION

Finally, the findings of systematic review conducted to investigate the effects of resistive exercise alone or in combination with aerobic regimes on respiratory parameters, concluded that there is a low evidence for the impact of resistance exercises in improving lung function and respiratory parameters. However, the indication of significant results of resistive exercises in improving lung function is a suggestive of future need of further researches to be conducted on this subject.

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