# 98. Exercise capacity: from elite athletes to severe impairment

### P839

Factors predicting exercise-induced oxygen desaturation in stable COPD Khaled Hussein<sup>1</sup>, <u>Atef Farouk Alkarn</u><sup>1</sup>, Samiaa Hamdi<sup>1</sup>, Raafat El-Sokkary<sup>1</sup>, Hamdy Shams<sup>2</sup>, <sup>1</sup>Department of Chest Diseases, Faculty of Medicine, Assiut University, Assiut, Egypt; <sup>2</sup>Cardiology Department, Faculty of Medicine, Assiut University, Assiut, Egypt

**Background and objective:** Some resting pulmonary function and blood gas parameters might predict exercise-induced oxygen desaturation in patients with stable COPD. We aimed at studying these factors.

**Patients and methods:** We tested 55 patients with stable COPD (FEV<sub>1</sub>/FVC%: 54.31). Resting pulmonary function, arterial blood gases, echocardiography, and incremental cardiopulmonary exercise testing were done for all patients. We diagnosed exercise-induced oxygen desaturation if O<sub>2</sub> saturation decreased  $\geq 4\%$  with exercise. We compared desaturated (DS) with non-desaturated (NDS) patients.

**Results:** Exercise induced oxygen desaturation (DS) occurred in 28 subjects while 27 were non-desaturated (NDS). FEV<sub>1</sub>% of predicted was significantly lower in DS (33.75±9.28) than NDS patients (49.49±19.86, P<0.001). Diffusing capacity DLCO % predicted was significantly lower in DS (47.35±19.62, P<0.001). Resting O2 saturation SaO2% was significantly lower in DS (91.9±2.88) than NDS patients (95.94±2.9, P<0.001). Resting PaCO<sub>2</sub> mmHg was significantly higher in DS (43.6±11.58) than NDS patients (95.97±0.001). Pulmonary artery systolic pressure mmHg was significantly higher in DS (42.21±11.90) than NDS (34.15±12.14, P<0.01). Medical Research Council MRC dyspnea score was significantly higher in DS (3.54±0.69) than NDS patients (2.44±0.97, P<0.001). On the other hand, there were no statistically significant differences in FEV<sub>1</sub>/FVC%, total lung capacity, residual volume, and resting heart rate between the DS and NDS patients.

**Conclusion:** FEV<sub>1</sub>%, DLCO, resting SaO<sub>2</sub>, resting PaCO<sub>2</sub>, pulmonary artery systolic pressure and MRC dyspnea score can predict exercise-induced desaturation in stable COPD.

### P840

# A 4-min, self-paced step test to assess exercise impairment in COPD patients GOLD I-to-IV

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**Background:** There is a long-standing interest in developing "field" exercise tests for patients with chronic obstructive pulmonary disease (COPD) which can be easily performed in the consulting room with a minimum of technical support. **Objectives:** To investigate whether a 4-min, self paced step test (4MST) would

be useful to assess exercise tolerance and oxyhemoglobin desaturation by pulse oximetry  $(SpO_2)$  in a large group of outpatients with COPD.

**Methods:** 191 patients (GOLD stages: 1= 16, II= 63, III= 79, IV= 33) prospectively underwent the 4MST. Patients were allowed to stop the test as needed and re-start it within the allowed 4-min.

**Results:** There were no significant test-related complications. There was a large variability in the steps climbed (ranging from low 20's to more than 100). Based on the tertiles of steps climbed, patients were separated into sub-groups of progressive impairment (Group A, N= 62; Group B, N= 61; Group C, N= 68). Group

A patients were significantly younger than those of Group B and C (p<0.05). The number of interruptions during the tests increased from Group A to C; in addition, this variable and the steps climbed were significantly correlated (r= -0.53; p<0.01). 11/16 GOLD I patients were on Group A whereas 30/33 GOLD IV patients were on Groups B or C (p<0.05). In addition, from 36 patients with disabling breathlessness (MRC scores IV to V) 30 of them were on Groups B or C (p<0.05). Decreases in SpO<sub>2</sub> corrected by steps climbed decreased as exercise tolerance diminished (p<0.05).

Conclusions: A 4-min, self paced step test (4MST) was useful in discriminating COPD patients into progressive levels of exercise and pulmonary gas exchange impairment.

### P841

Factors associated with aerobic fitness in adolescents with asthma <u>Sveinung Berntsen<sup>1</sup></u>, Karin C. Lødrup Carlsen<sup>2,3</sup>, Sigmund Alfred Anderssen<sup>4</sup>, Petter Mowinckel<sup>2</sup>, Kai-Håkon Calrsen<sup>2,3,4</sup>. <sup>1</sup>Department of Public Health, Sport and Nutrition, University of Agder, Kristiansand, Norway; <sup>2</sup>Department of Paediatrics, Oslo University Hospital, Oslo, Norway; <sup>3</sup>Faculty of Medicine, University of Oslo, Norway; <sup>4</sup>Department of Sports Medicine, Norwegian School of Sport Sciences, Oslo, Norway

Background: In adolescents with asthma, information on factors associated with aerobic fitness levels is limited. The present study aimed to determine if physical activity as well as skin fold thickness, asthma exacerbations, use of inhaled corticosteroids or lung function influences direct measurements of peak oxygen uptake (VO2peak) in adolescents with asthma.

Methods: From the general population based birth cohort, Environment and Childhood Asthma study in Oslo, Norway, in a nested case-control study 86 13-years old adolescents with and 76 without asthma performed maximal running on a treadmill with VO2peak measured. The sum of four skin fold thicknesses was recorded, followed by wearing an activity monitor for four consecutive days. Lung function was measured by maximum forced expiratory flow-volume curves and body plethysmography. Asthma exacerbations and use of medication were registered by parental structured interview. Data were analyzed using multiple regression analysis.

Results: Vigorous physical activity (coefficients with 95% confidence intervals; 1.73 (0.32, 3.14)) and body fat -0.35 (-0.41, -0.28)) were significantly associated with VO2peak in adolescents with asthma. Neither use of inhaled corticosteroids, lung function nor number of asthma exacerbations was associated with VO2peak when taking physical activity and skin fold thickness into account. In the adolescents without asthma only skin fold thicknesses was associated with VO2peak.

Conclusions: VO2peak appears to be determined by vigorous physical activity level and skin fold thickness in Norwegian adolescents with asthma and not by asthma-related factors such as use of inhaled corticosteroids, lung function nor number of asthma exacerbations.

# P842

#### Predicting VO<sub>2</sub>max in elderly: Could equations established in younger subjects be used?

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Background: Equations recommended by the ERS/ATS for estimating maximal oxygen consumption (VO2max or peak) have been established in population samples with few subjects > 70 years. As a result, predicted values (pred) for elderly are largely extrapolated from linear models.

We aimed to determine if VO2max values measured in people aged >70 years diverged from pred using recommended equations.

Methods: We measured VO2peak in 184 subjects (40% women and 60% men) aged 69-89 years and used Hansen's equations for estimating VO<sub>2</sub>max.



Results: There were 49 non-diseased (ND) males and 62 with at least one disease (D) (COPD, cancer, coronary disease). In females, 34 were ND, and 39 had at (D) (Coll D, enter, even and a second product of the second produ L/min, 111% of pred, and was 1.07 (0.26) L/min, 102% of pred, in D females (NS).

4% of ND males and 3% of ND females had  $VO_{2peak} < 70\%$  of pred. The mean difference between pred  $VO_{2max}$  and measured  $VO_{2peak}$  was -0.09 L/min in ND males and -0.11 L/min in ND females. 90% of (predicted-measured VO<sub>2</sub>max) differences ranged between -0.77 and +0.58 L/min in ND males, and -0.57 and +0.36 L/min in ND females. Subjects with higher level of activity/week had higher VO2max (p<0.001.

Conclusions: These results support the use of Hansen's equations in elderly in populations comparable to ours

#### P843

Reference values for cardiorespiratory fitness in a 20 - 85 year old population Elisabeth Edvardsen<sup>12</sup>, Bjørge H. Hansen<sup>2</sup>, Ingar M. Holme<sup>12</sup>, Sindre M. Dyrstad<sup>3</sup>, Sigmund A. Anderssen<sup>1</sup>. <sup>1</sup> Department of Pulmonary Medicine, Oslo University Hospital, Ullevål, Oslo, Norway; <sup>2</sup>Department of Sports Medicine, Norwegian School of Sport Sciences, Oslo, Norway; <sup>3</sup>Department of Education and Sport Science, University of Stavanger, Norway

Background: Existing reference values used during clinical exercise testing have been obtained with rather small none randomly sample sizes, lack of women and elderly or poor maximal end-criteria. The aim was to establish reference values during maximal exercise in a representative sample of men and women.

Methods: 904 randomly sampled healthy men and women (20 - 85 yr old) exercised on a treadmill using a modified Balke protocol to exhaustion. Results: 759 participants met the criteria for an acceptable  $VO_{2max}$  based on

RER≥1.10 or BORG≥17. In the age group 20-29, the VO<sub>2max</sub> (ml kg<sup>-1</sup>  $\min^{-1}$ ) was 40.3 (SD 7.1) and 48.6 (SD 9.6) in women and men, respectively. A linear decline (8% per decade) was observed after the age of 30 in both genders.

Physiological responses at maximal exercise, mean (SD)

	Age (yrs)					
	20-29	30–39	40-49	50-59	60–69	70-85
Heart rate (beat/min)	192 (7.7)	187 (8.8)	181 (11.2)	171 (13.0)	164 (13.4)	155 (14.0)
Oxygen pulse (ml/beat)	17.0 (4.2)	17.2 (4.3)	16.2 (4.5)	15.5 (4.1)	14.6 (3.6)	12.1 (3.7)
Minute ventilation						
(L/min)	119 (28)	118 (30)	106 (31)	96 (27)	88 (23)	68 (21)
Breathing reserve (%)	28 (12)	24 (13)	25 (15)	27 (13)	26 (14)	34 (13)
RER	1.22 (0.09)	1.23 (0.10)	1.21 (0.10)	1.19 (0.11)	1.17 (0.11)	1.13 (0.11)
SBP (mmHg)	169 (21)	174 (21)	182 (24)	186 (25)	193 (27)	197 (28)
DBP (mmHg)	74 (15)	76 (15)	77 (20)	81 (17)	81 (18)	81 (18)
[Blood lactate] (mM)	10.9 (2.6)	11.5 (2.8)	10.3 (2.9)	8.6 (2.8)	7.4 (2.5)	5.9 (2.2)
BORG scale (6-20)	17.9 (1.3)	17.9 (1.2)	17.5 (1.4)	17.5 (1.3)	17.5 (1.2)	17.6 (1.0)

SBP, systolic blood pressure; DBP, diastolic blood pressure.

Conclusions: The present study establishes VO2max and other typical cardiorespiratory variables during maximal exercise and may be used as reference values.

#### P844

# Exercise in patients with lymphangioleiomyomatosis: Performance and the prevalence of dynamic hyperinflation

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Introduction: Previous studies suggested multiple factors for exercise cessation in LAM. Although airflow limitation is frequent in LAM, the dynamic hyperinflation (DH) and its repercussions during exercise have not been evaluated yet.

Objectives: To evaluate the prevalence and repercussions of DH in LAM and also the dynamic responses during maximal exercise, in comparison to controls.

Methods: 42 patients performed pulmonary function tests (PFT) and symptomlimited incremental cycle exercise, in comparison to ten age-matched healthy women. Dyspnea intensity, inspiratory capacity, oxygen saturation (SpO2), cardiac, metabolic and respiratory variables were obtained during exercise. 6MWT was performed by LAM patients indeed.

Results: Compared to controls, LAM had higher baseline dyspnea, obstructive pattern, air trapping and lower DLCO in PFT. In LAM, maximal exercise performance was reduced, associated with ventilatory limitation, greater dessaturation and dyspnea. DH occurrence was higher in LAM than controls (55 vs. 0%), with a significant correlation to airflow obstruction, air trapping and DLCO. Patients who developed DH had not only a ventilatory contribution to exercise cessation on cycling, but also greater dessaturation and dyspnea intensity during 6MWT, compared with non-DH subgroup.

Conclusions: Ventilatory limitation is an important reason for exercise cessation in LAM, compared with controls. DH was prevalent and had association with severity of disease, higher dyspnea and lower SpO2. On 6MWT, dessaturation and increased dyspnea were greater in DH subgroup. Future interventions to reduce DH might contribute to improve dyspnea and exercise tolerance in LAM.

#### P845

Exercise respiratory cycle time components in patients with emphysema <u>Alessandro Maria Ferrazza</u>, Patrizia Paoletti, Gabriele Valli, Paolo Onorati, Dario Martolini, Michela Mordenti, Francesco Vaccaro, Paolo Palange. Department of Public Health and Infectious Diseases, Lung Function Unit, Sapienza University of Rome, Italy

**Background:** We have recently demonstrated that in patients with COPD the severity of emphysema (E) measured by high resolution computed tomography (HRCT) correlated with: ratio VTpeak/FEV1; VE/VCO2 slope and PETCO2 values at peak exercise. The aim of this study was to further investigate if exercise respiratory cycle time components correlated with % of E measured by HRCT. **Method:** Twelve patients (age =  $65\pm8$  yrs; FEV1 =  $55\pm17\%$ pred) with moderate to severe E (quantified by lung HRCT as % voxels < -910 HU) were evaluated with incremental cardiopulmonary exercise testing (CPET). Mean inspiratory time

(TiM), mean total respiratory cycle time (TtotM), mean expiratory time during exercise (TeM) and mean expiratory time during the last third of exercise (TeM-end), has been calculated.

**Results:** Both TeM and TeM-end had a good linear correlation with % of E (r = 0,61; p = 0,004 and r = 0,63; p = 0,003).



Moreover, by dividing the patients in two groups based on the % of E (>50% and <50%), we observed that patients with higher % of E had longer TeM (TeM: 1,72±0,26sec vs 1,34±0,27sec, p = 0,005) and TeM-end. A good linear correlation has been observed also between TeM and PETCO2 and VE/VCO2 (r = 0,64; p = 0,002 and r = 0,7; p = 0,0005). TeM did not correlated with resting lung function values or inspiratory capacity (IC).

**Conclusion:** The data confirm that distinct physiologic response pattern can be detected at CPET in these patients.

# P846

# Skeletal muscle oxygenation during exercise in patients with chronic respiratory failure

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**Background:** Muscle oxygenation correlates with systemic oxygen uptake  $(VO_2)$  in normal subjects, however whether this relationship exists chronic respiratory failure (CRF) patients remains unclear.

**Objectives:** The purpose of this study was to investigate the influence of skeletal muscle oxygenation on VO<sub>2</sub> during exercise in CRF patients.

**Methods:** Ten chronic obstructive pulmonary disease and two sequelae of pulmonary tuberculosis patients performed an incremental cycle ergometer exercise test. We measured ventilation, pulmonary gas exchange and SaO<sub>2</sub>. We also measured tissue oxygen saturation (StO<sub>2</sub>) in the vastus lateralis with continuous wave near-infrared spectroscopy. We calculated the muscle oxygen extraction rate (MOER) based on SaO<sub>2</sub> and StO<sub>2</sub>. In addition, we performed regression analysis to examine the relationships between the VO<sub>2</sub> obtained during exercise testing and the mean values of SaO<sub>2</sub>, StO<sub>2</sub>, heart rate (HR), and MOER for each 30-second interval of the tests. Finally, we analysed the relationships between the peak value of oxygen uptake (VO<sub>2peak</sub>) and the slopes of HR/VO<sub>2</sub>, SaO<sub>2</sub>/VO<sub>2</sub>, StO<sub>2</sub>/VO<sub>2</sub>, and MOER/VO<sub>2</sub>.

**Results:** With the increasing exercise intensity, many subjects showed a gradual decrease in  $StO_2$  and  $SaO_2$ , but a gradual increase in HR and MOER.  $VO_2$  was negatively correlated with  $StO_2$  and  $SaO_2$ , and was positively correlated with HR and MOER. However,  $VO_{2peak}$  was not correlated with any of the slopes.

**Conclusions:** VO<sub>2</sub> is highly influenced by oxygen utilization in exercising muscles, as well as by blood oxygenation levels and cardiac function. However, the impact of skeletal muscle utilization during exercise on VO<sub>2peak</sub> varied greatly among the patients.

# P847

# Inspiratory muscle constraint during exercise in patients with pulmonary arterial hypertension

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We examined the impact of potential inspiratory muscle constraint on dynamic operating lung volumes response during symptom-limited incremental cardiopulmonary cycle exercise testing (CPET) in patients with pulmonary arterial hypertension (PAH).

Thirty-three young non-smoking PAH patients (idiopathic=26; heritable=7) with normal body mass index and no spirometric evidence of obstructive ventilatory defect (FEV<sub>1</sub>/FVC=115±10% predicted) performed a CPET to limit of tolerance. Ventilatory profile, operating lung volumes [derived from inspiratory capacity (IC) measurements] and inspiratory flow reserve (IFR), an indirect index of inspiratory muscle constraint/fatigue,were assessed throughout CPET.

Twenty-two patients (67%) decreased IC (i.e., dynamic hyperinflation) throughout exercise by 0.50L (PAH-H), whereas the remaining patients (33%) increased IC by 0.36L (PAH-NH). V'E and V'O2 at peak exercise were comparable between the two groups. Despite these differences in operating lung volumes response, IFR at peak exercise was not statistically different between PAH-H and PAH-NH ( $1.9\pm1.0$  vs  $2.0\pm0.8L/s$ , p=0.7).

Both PAH-H and PAH-NH achieved inspiratory tidal flows that approached a similar percentage of the maximal available inspiratory flows (i.e., similar IFR), suggesting that the inspiratory flow-generating reserve of the inspiratory muscles at peak exercise was similar (but occurred at different operating lung volumes). The presence of inspiratory muscle constraint/fatigue and its contribution in modulating the dynamic operating lung volumes response to CPET is unlikely.

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#### P848

# A metabolic evaluation of a group of obese children: Oxygen consumption (VO2) and power

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Obesity, which has been considerably increasing in the last decades, is related to significant metabolic alterations.

The aim of this study was to evaluate whether this condition can also alter the VO2 (considered as the best assessment of cardiorespiratory form in healthy children) and the power in a group of obese children compared to a group of control children. We tested 98 children: 42 controls and 56 obese children. Each child underwent the incremental test on the cycle ergometer according to a protocol of increasing effort.

VO2 values were 2027.6 ml/min for the group of controls and 2078.0 ml/min for the obese children (p>0.05); instead, the values of VO2/kg were lower in the obese children 32.3 ml/kg compared to the group of controls 38.7 ml/kg/min (p<0.01). The higher value of power was obtained in the group of control children (140 watt) and lower in the obese (120 watt) (p<0.05); this parameter normalized for the mass was higher in the group of controls (2.7 watt/kg) compared to obese children (1.9 watt/kg) (p<0.01).

Given the greater body mass of obese due to an increased fat component, it is not surprising that the VO2 is higher. These subjects must in fact move a large mass, with a considerable consumption of energy, to the detriment of their ability to work. The VO2/kg values are lower in the obese as cardiac or metabolic disease limit the peripheral oxygen consumption. In obese children the power values are lower as the lean body mass consumes less oxygen that fat body mass, it produced less work therefore less power. Power/kg is lower in obese children due to their larger mass.

#### P849

#### Determinants of exercise capacity in patients with COPD without other comorbidities

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Introduction: The 6 min walking test (6MWT) is frequently used to assess exercise limitation and exertional dyspnoea in COPD. Age, sex, metabolic, cardiovascular, neuromuscular and respiratory variables can contribute to determine the final individual value of the 6MWT.

Aims: To evaluate exercise performance with the 6MWT in COPD patients free of other co-morbidities.

Methods: From the Bode International Cohort Study we selected 148 men with COPD and no other cardiovascular, cerebrovascular, metabolic o neuromuscular disorder. In addition, patients who were taking beta-blockers or anti-hypertensives were also excluded. A pre-specified protocol including two standardized 6MWT was applied to all patients.

**Results:** The mean  $\pm$  SD of the post bronchodilator FEV1% predicted and 6MWT was 62±21 and 398±99 meters respectively. Walked distance correlated significantly with age, height, weight, baseline dyspnoea (as assessed by the MRC scale), CAT questionnaire, spirometric parameters, lower heart rate (HR) and higher basal O2 Saturation (O2Sat). After forward stepwise multiple linear regression to evaluate the predictive value of the different factors to explain the 6MWD, four variables stay in the model: age, MRC score, change in O<sub>2</sub>Sat and change in HR from baseline to the end of the test (adjusted  $r^2 = 0.33$ , p<0.001).

Conclusions: In COPD without comorbidities, age, exertional dyspnoea, and higher changes in O2Sat and HR were the most important determinants of exercise capacity

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# P850

Exercise precipitates lung function derangement in early diabetes Anupama Gupta, Neena Mishra, Rajesh Gupta, Sushma Sood. Physiology, Pt BD Sharma PGIMS, Rohtak, Haryana, India Physiology, Pt BD Sharma PGIMS, Rohtak, Haryana, India TB & Respiratory Medicine, Pt BD Sharma PGIMS, Rohtak, Haryana, India Physiology, Pt BD Sharma PGIMS, Rohtak, Haryana, India

Association between diabetes and pulmonary function has been inconsistent in various studies

Aim: Our study aims 1. To find out minimal early changes in lung functions in diabetics i.e. without any complications. 2. To reveal abnormality of lung functions on minimal physical exertion (or exercise).

Methods: In 30 patients of type-2 DM without complication, nine spirometeric parameters were recorded at rest, immediately after exercise (Mag cycle ergo meter, starting at 60 revolutions/minute against zero work load for a period of 5 minutes) and 5 minutes after stopping exercise and compared with matched healthy subjects as controls using paired & unpaired 't' test and 'p' values.(non randomized)

Observations: 1. FEV1/FVC%, FEF50 and FEF75 were significant low in diabetics as compared to controls and further deteriorated on exercise indicating small airway and obstructive lung disease even in early diabetics i.e. Without complication

2. Though FEV1, FVC & MVV in diabetics were comparable to controls but contrarily failed to rise on exercise suggest that diabetics fatigue early.

3. On 5 minutes of rest after exertion (exercise) FVC, FEV1/FVC%, FEF75 & MVV failed to recover hints that mild exercise precipitates underlying restrictive abnormality of lung in diabetics.

Discussion and conclusion: From the observations we can make out that early changes in lung functions are obstructive in early diabetics taken as uncomplicated, with musculo-skeletal and connective tissue dysfunctions underlying, the restrictive abnormality is precipitated even on mild exercise.

# P851

Daily physical activity in patients with chronic obstructive pulmonary disease Stefanie Zogg<sup>1,2</sup>, Selina Dürr<sup>1,2</sup>, Sabrina Maier<sup>1</sup>, Esther Helen Steveling<sup>1</sup>

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Background: Patients with chronic obstructive pulmonary disease (COPD) are known to be significantly inactive in daily life. For the development of adequate intervention strategies, it might be a good approach to quantify the amount of daily physical activity (PA).

Objective: The primary aim of this study was to examine PA levels across COPD stages and COPD risk groups

Method: Stable patients with COPD Gold stages I-IV were recruited at the University Hospital of Basel, Switzerland. Participants were classified into four risk groups A to D according to the revised Gold guidelines of December 2011. PA was measured by the validated SenseWear Mini Armband on seven consecutive days. Average daily number of steps, activity based energy expenditure (AEE) and time spent in PA above 3 METs (PA3) were chosen as primary outcomes. **Results:** Complete data were available from 77 individuals (59.7% male, age

66.9±9.8yrs, Body Mass Index (BMI) 25.8±5.5kg/m<sup>2</sup>, steps 4760±3383, AEE 436.1±381.5cal, PA3 96±84min). Steps (p<0.01), AEE (p<0.01) and PA3 (p<0.05) were all found to be significantly higher in COPD risk group A compared to B. In contrast, only steps were observed to be significantly lower in COPD stage IV compared to I and II (p<0.01). BMI showed a negative correlation with

associated with steps (r=-0.24, p<0.05), while gender was not found to correlate significantly with any of these measures. Conclusion: This study provides evidence that daily PA is significantly impaired in severe COPD stages and risk groups compared to early ones. However, COPD risk groups seem to reflect disease severity more accurately than COPD stages do.

AEE (r=-0.27, p < 0.01) and PA3 (r=-0.44, p < 0.01). Age was found to be inversely

# P852

#### Effect of exercise training on ventilation in patients with COPD or chronic heart failure

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Ventilatory efficiency is reduced in patients (pts) with COPD or chronic heart failure (CHF) resulting in abnormal dyspnoea during exercise. The aim of the study was to evaluate the effect of exercise training on ventilation in these pts. Methods: 25 COPD pts (11 males; 64±9 years old, GOLD 3-4) and 25 CHF pts (23 males, 55±10 years old, NYHA class II-III, ejection fraction  $\leq$  35%) underwent maximal exercise test pre and post rehabilitation programme (RP) measuring oxygen uptake (V'O<sub>2</sub>), carbon dioxide output (V'CO<sub>2</sub>) and ventilation (V'E). The ventilatory efficiency was evaluated using the V'E/V'CO2 slope. Breathing pattern was evaluated using iso-ventilation, i.e. maximal V'E, tidal volume (VT) and respiratory rate (RR) pre RP compared to the same parameters during iso-V'O2 post RP. Exercise training in the RP consisted of endurance and strength training 5 days a week for six weeks.

Results: Exercise endurance increased and ventilatory requirements reduced post RP. Breathing pattern was improved in COPD pts but ventilatory efficiency was unchanged in both groups (Table 1).

Table 1

	COPD	patients	CHF patients		
	Pre	Post	Pre	Post	
V'O2max (ml/kg/min)	9.8±4.5	10.9±5.4*	$14.4{\pm}6.9^{\dagger}$	17.5±9.1*	
V'E/V'CO2 slope	36.2±7.2	34.7±7.6	35.0±9.1	34.3±9.7	
Iso-V'E (L/min)	$30.9 \pm 9.6$	28.3±8.7*	45.7±17.6 <sup>†</sup>	40.9±15.6*	
Iso-VT (L)	$1.07 \pm 0.33$	1.17±0.36*	$1.58 {\pm} 0.56^{\dagger}$	$1.56 {\pm} 0.56$	
Iso-RR (per min)	$29.4 \pm 5.1$	24.4±2.3*	$29.8 {\pm} 6.1$	$26.9 \pm 5.6*$	

Data are presented as mean ± SD. \*p<0,05 post RP vs pre; <sup>†</sup>p<0,05 CHF vs COPD.

Conclusion: Exercise training did not improve ventilatory efficiency but reduced ventilatory requirements during heavy exercise giving prospect of less dyspnoea during effort in these pts.

#### P853

#### Short-term ingestion of salbutamol increases isometric muscle power in endurance athletes

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Rationale: Salbutamol is on WADA's prohibited but is allowed by athletes in therapeutic doses. Positive effects of oral salbutamol have been shown in active males and females. Yet, studies are needed examining the effects in athletes. Furthermore, no studies have examined whether oral salbutamol improves isometric muscle power and endurance. We examined whether acute and short-term intake of oral salbutamol improved isometric muscle power and endurance, and submaximal exercise performance in endurance athletes.

Method: Twenty non-asthmatic endurance athletes (M), aged 25.8±4.4yrs, watt<sub>max</sub> 440.9±29.3W, were enrolled in a randomized double-blinded parallel study, into either oral salbutamol 8 mg (SAL) or placebo (PLA). The protocol consisted of three tests. Isometric muscle power of m. quadriceps was measured by maximal voluntary contraction, followed by an isometric endurance test of m. deltoideus to exhaustion and a submaximal cycling test to exhaustion at 90% of VO2max (TTE@90%). The protocol was performed at baseline, after acute ingestion, and after 14 days of daily ingestion.

Results: Short-term intake of salbutamol significantly increased isometric muscle power, 709±115N versus 662±100N at baseline (p<0.05). Furthermore, there was a significant linear trend of increased isometric muscle power with SAL throughout the intervention (p<0.05). No differences were found in the PLA-group. Neither SAL nor PLA had any impact on isometric endurance or TTE@90%.

Conclusions: Short-term intake of salbutamol might augment training response and increase isometric muscle power in endurance athletes. Salbutamol had no effect on submaximal exercise at 90% of VO2max or on isometric endurance.

#### P854

# Effects of acute and two week intake of salbutamol on anaerobic power and

**capacity during repeated bouts of exercise in elite cyclists** <u>Morten Hostrup</u><sup>1,2</sup>, Anders Kalsen<sup>1,2</sup>, Jens Bangsbo<sup>2</sup>, Vibeke Backer<sup>1</sup>. <sup>7</sup>*Respiratory Research Unit, Bispebjerg University Hospital,* <sup>2</sup>*Department of* Exercise and Sport Sciences, University of Copenhagen, Denmark

Rationale: Salbutamol, was of 2010 relieved from WADA's prohibited list needing a strict diagnosis of asthma, and can now be used more freely among athletes. Some studies have showed enhancing effects of oral salbutamol on anaerobic power in recreational men and women. However, no studies have investigated this in elite athletes. The aim of this study was to examine whether oral salbutamol, taken acutely and over a period of two weeks, increases anaerobic power during repeated Wingate tests in elite cyclists.

Method: We enrolled 20 non-asthmatic elite cyclists (M), aged 25.8±4.4yrs,  $VO2_{max}$  68.6±5.8 ml/min/kg, and a training volume of 14.4±3.6 h/wk. The cy clists were randomized into either oral salbutamol 8 mg (SAL) or placebo (PLA) in a double-blinded parallel study. The protocol consisted of three 30-s Wingate tests separated by two minutes of recovery. The intervention consisted of study visits at baseline, after acute ingestion and after two week ingestion taken two-three hours prior to the cyclists' regular training.

Results: Two week ingestion of salbutamol significantly increased peak power in the first (p<0.05) and second (p<0.001) Wingate, 894±48W and 885±51W versus 861±53W and 848±54W at baseline. Furthermore, the SAL-group had a significant higher mean peak power over 5s at both the first (p<0.05) and the second (p<0.05) Wingate, with 861±42W and 829±56W versus 809±58W and 795±59W at baseline. Acute ingestion of salbutamol didn't increase any parameter in the SAL-group. No differences were found in the PLA-group.

Conclusions: Two week daily intake of salbutamol taken prior to training improves anaerobic power in elite cyclists.

# P855

### Inspiratory muscle warm-up does not improve cycling time trial performance Ian Gregson<sup>1</sup>, Dean Mills<sup>1</sup>, Javier Gonzalez<sup>2</sup>, Graham Sharpe<sup>1</sup>

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Combining an inspiratory muscle warm-up (IMW) with a sport specific warm-up improved intermittent running (Tong and Fu. Eur J Appl Physiol 2006; 97:673-680) and 6 min rowing time trial (Volianitis et al. Med Sci Sports Exerc 2001; 33:1189-1193) performances more than a sport specific warm-up alone. This study tested the hypothesis that an IMW would also improve cycling time trial performance. Ten competitive cyclists (VO2max 64.7±8.9 mL/kg/min) performed three 10 km cycling time trials preceded by either no warm-up (CONT), a cycling specific warm-up (CYC) comprising three consecutive 5 min bouts at powers corresponding to 70, 80, and 90% of the aerobic gas exchange threshold, or a cycling specific warm-up preceded by an IMW (CYC+) comprising two sets of 30 inspiratory efforts against a pressure-threshold load of 40% maximal inspiratory pressure (MIP). During CYC and CYC+ the cycling warm-up was followed by a 2 min rest period before the start of the time trial.

Performances during CYC (14.75±0.79 min) and CYC+ (14.70±0.75 min) were not different, although both were faster than CONT ( $14.99\pm0.90 \text{ min}$ ) (P < 0.05). At 2.5 km intervals heart rate, rating of perceived exertion for leg and breathing discomfort, blood lactate concentration and pH, were not different between CYC and CYC+. Baseline MIP during CONT and CYC were 151±31 and 156±39 cmH2O, respectively, and these were unchanged following the time trial. IMW increased MIP from 152±27 to 164±27 cmH2O and no further change was observed following the time trial.

In conclusion, improvements in 10 km cycling time trial performance following a specific cycling warm-up were not magnified by the addition of a specific inspiratory muscle warm-up.

# P856

# Minute ventilation (V'<sub>E</sub>) and heart rate (HR) relationship during exercise in chronic cardiac and pulmonary diseases

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We have demonstrated in healthy subjects that the rate of increase in minute ventilation over heart rate ( $\Delta V'_E / \Delta HR$ ), during incremental exercise, is described by a bilinear response, with a slope's change at the ventilatory compensation point (VCP) (Onorati P., Eur J Appl Physiol, 2008;104:87-94;Med Sci Sports *Exerc 2012 in press*). We aimed at analyzing the exercise  $\Delta V'_E / \Delta HR$  response in patients with chronic cardiopulmonary diseases.

Methods: Patients with chronic obstructive pulmonary disease (COPD) (n=10) and cardiovascular diseases (CVD) (Pulmonary Arterial Hypertension, PAH, n=9; and Chronic Heart Failure, CHF, n=10) underwent one-minute incremental cvcling exercise. Gas exchange, V'<sub>E</sub>, HR were measured breath-by-breath.  $\Delta V'_E / \Delta HR$ response, before  $(S_1)$  and after the VCP  $(S_2)$  were computed by linear regression analysis.

**Results:** In all patients we observed a linear response of the  $\Delta V'_E / \Delta HR$  relationship; in COPD patients S<sub>1</sub> was steeper vs PAH and CHF and approached maximal voluntary ventilation (MVV). S<sub>2</sub> slope was observed manly in CVD patients and approached maximal predicted HR



A good agreement (Bland-Altman test) for VCP detection was observed between  $\Delta V^{\prime}{}_{E}/\Delta HR$  vs the ventilatory equivalent for CO\_2 (V^{\prime}{}\_{E}/V^{\prime}CO\_{2}) methods. Conclusions: In patients with COPD and CVD, the  $\Delta V'_E / \Delta HR$  response during cycling incremental exercise can be utilized to discriminate between ventilatory and circulatory limitation.

#### P857

#### Influence of ventilatory inefficiency in to limit exercise capacity in COPD patients

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Background: We recently demonstrated an influence of Ventilatory efficiency (VE/VCO<sub>2</sub>) over exercise capacity in COPD (Resp Care 2012 in press). Purpose: to demonstrate increase of ventilatory inefficiency depending on the severity of COPD, and its influence into reduce exercise capacity.

Methods: 58 Gold I - III patients, mean age 61, mean FEV1: 98, 68.5 and 44.3%, mean DCO: 68, 59.5 and 45%. A cardiopulmonary stress test measuring Power (Wmax), Oxygen consumption (VO2max), VE/VCO2, expiratory flow limitation (EFL) and dynamic end expiratory volume (DEELV) was performed. In patients with hyperinflation correlations and multiple regressions between BMI, EFL, DEELV and VE/VCO2 over Wmax and VO2max were calculated.

Results: Patients ended the test due to dyspnea with increased VE/VCO2 (mean 34). Depending on the severity of COPD, VE/VCO2 was higher. 36 patients presented hyperinflation (mean DEELV 0.5 L), with a reduction in Wmax and in VO2max (mean: 63 and 76%). Significative correlation was demonstrated between VE/VCO2 over VO2max and Wmax (r: -0.5 and -0.5). In multiple regression the relation between VE/VCO2 and Wmax and VO2max was significative (p< 0.05 and <0.05), but not to BMI, EFL and DEELV.

Conclusions: In COPD patients ventilatory inefficiency increases depending on the severity and is related with a reduction in the exercise capacity. Ventilatory inefficiency is an independent factor in to reduce exercise capacity in COPD.

#### P858

#### Respiratory muscle endurance training (RMET) with normocapnic hyperpnea (NH) improves ventilatory function and exercise performance in triathletes

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Recent studies show that RMET reduces dyspnea perception, improves exercise performance and decreases VE during exercise in healthy subjects. Aim: To evaluate the effect of 5 weeks of RMET with NH by means of Spirotiger®

on respiratory function, cycling and running performance in triathletes

Methods: 15M triathletes (aged 21-43) were allocated in 2 groups: RMET (10M) and Control (5M) group.

At baseline (T0) athletes underwent: pulmonary function tests (FEV1, FVC, MIP, MVV) and exercise tests (maximal incremental and endurance cardiopulmonary tests performed with both cycle ergometer and treadmill) and repeated the same tests after 5 weeks (T1).

RMET group trained at home for 5 weeks: 20 min daily at the same ventilation level measured at the RC point during incremental test.

Between T0 and T1 all subjects maintained the same training program.

Results are reported in Table 1. The trend of VO2, VE and RR showed lower values after RMET (p<0,05; ANOVA test)

No change was found in control group.

Table 1

	FEV1 (%)	FVC (%)	MIP (cmH2O)	MVV (l/min)	Max Watt	Max Speed (km/h)	Borg dyspnea endurance test
T0	114±9	120±10	93±29	213±17	389±106	18±2	7/10±0,7
T1	115±11	$120{\pm}10$	97±25*	231±18*	429±119*	19±2*	6/10±0,5*

Mean±SD. \*p<0,05; T test.

**Conclusion:** RMET significantly improves MIP and MVV in triathletes and increases exercise performance. Furthermore the VE becomes more efficient as shown by the reduction of VE, RR and by the lower dyspnea Borg score; the new data is the lower trend of VO2 during incremental test.