P2164
Influence of gas concentration and measurement interval on the reproducibility of non-invasive cardiac output determination by inert gas rebreathing in pulmonary healthy patients
Frederik Trinkmann, Matthias Sampels, Ursula Hoffmann, Martin Borchgrefe, Jens J. Kaden, Joachim Saur. 1st Department of Medicine, Universitätsmedizin Mannheim, Mannheim, Germany

Background: Cardiac output (CO) is an important physiological parameter. In recent comparative studies non-invasive inert gas rebreathing (IGR) showed promising results. The aim of the prospective study was to evaluate the influence of gas concentration and measurement interval on the reproducibility.

Methods: We performed four series with two measurements for a gas bolus of 7.5%, 10%, 15% and 20% in supine position, respectively, and at intervals of 2 or 5 minutes. To rule out ventilation and diffusion disorders a bodyplethysmography was performed.

Results: A total of 384 measurements could be performed in 48 subjects, in 34 with an interprocedural interval of 5 minutes and in 14 of 2 minutes. For a fraction of 7.5% and an interval of 2 minutes we found a reproducibility of $-0.8 \pm 1.1 \text{ l/min}$ compared to 5 minutes with $+0.1 \pm 0.6 \text{ l/min}$ ($p < 0.001$). Rising gas concentration improved the reproducibility, for an interval of 5 minutes and a 20% gas bolus fraction no statistically significant difference was detected ($p = 0.88$).

Conclusions: With an interval of 5 minutes a good reproducibility of the IGR measurements could be shown for all gas bolus fractions. For an interval of 2 minutes and low gas concentration we found a statistically significant reduced reproducibility. Using a 20% gas bolus the reproducibility reached the results of those of the 5 minute interval. This is particularly interesting for the determination of CO with a given small time frame, e.g. during spiroergometry. For the final assessment, however, additional studies with patients suffering from lung diseases are needed.
P2165
Pulse oximetry during saline challenge in vocal cord dysfunction and airway hyper-responsiveness
Alfonsen Upham1, Jeffrey Pretto1,2, Michael Hensley1,2. 1Department of Respiratory & Sleep Medicine, John Hunter Hospital, Newcastle, New South Wales, Australia; 2School of Medicine and Public Health, University of Newcastle, New South Wales, Australia

The hypotonic saline challenge (HSC) is a commonly used diagnostic tool to assess airway hyper-responsiveness (AHR) and vocal cord dysfunction (VCD). Dyspnoea during testing is not uncommon and we postulated that oxygen desaturation may be a causative factor.

**Aim:** To document the degree of arterial desaturation during saline challenge and compare SpO2 changes in AHR, VCD and negative responses.

**Method:** SpO2 (Nellcor N959) was continuously recorded during 78 consecutive HSCs. SpO2 data was averaged over 32 seconds and minimum values used for analysis. Change in dyspnoea score (Borg) during the challenge was also recorded. Results were classified as AHR (change in FEV1 ≥ 15%), as VCD (change in MIF ≥ 20%) or negative otherwise.

**Results:** Mean (SD) FEV1 was 86 (15%) predicted for AHR (n=20), 92 (18%) for VCD (n=18) and 94 (18%) for negative results (n=40). There was a consistent trend in SpO2 for all subject groups with significant desaturation during the final doses of saline and bronchodilatation (ANOVA p<0.001), and consistent resaturation during spirometric efforts. Mean (SD) maximum falls in SpO2 of 4.3% (2.7%) were observed for AHR, 4.1% (2.0) for VCD and 4.4% (2.7) for negative results. There was no relationship between change in dyspnoea and degree of desaturation (p=0.43).

**Conclusion:** Hypotonic saline challenge causes a significant and reproducible pattern of arterial desaturation irrespective of the test response. These data would be consistent with progressive hypoventilation due to HSC rather than indicating desaturation due to worsening ventilation-perfusion mismatching. Hypoxaemia does not appear to be the primary cause of dyspnoea during HSC.

P2166
A randomised cross-over clinical testing of portable oxygen concentrators in patients with COPD
Anabelle Couillard, Dan Veale, Didier Forest, Boris Melloni, Philippe Sauder, Jean-François Muir. Maison du Poismon, Fédération ANTADIR, Paris, France

Portable oxygen concentrators (POC) deliver oxygen via intermittent demand valves (IDV). this merit comparison with standard continuous flow oxygen (CFO). We have performed a multicenter comparison of 4 POC in a cross in study of 74 patients with COPD (age 67±10, FEV1 41±20% predicted). Each patient tested one of 4 POC at rest and during a six minute walk test (6MW), with oxygen saturation recording (SpO2). Noise and discomfort were evaluated by visual analogue scales (VAS).

**Results:** Mean 6MW distance was 388±114 with POC and 315 ±611 with CFO (p<0.06). However the distance walked with POC was clinically significantly less (by > 10%) than CFO in 23% of patients and significantly better than CFO (by >10%) in 13.5% of patients. Dyspnoea during 6MW by VAS was identical for both types of device. 55.5% of patients had SpO2 fall with both devices and 27% no fall in SpO2. 13.5% had SpO2 fall with POC at the same level as without. Overall patients appreciate the POC because of security of oxygen supply. However, they judged POC oxygen delivery significantly less annoying and noisier than CFO.

**Conclusion:** POC devices with demand valve oxygen delivery had similar efficacy to CFO devices but were noisier and less comfortable. Prescription of such devices needs to be individualized as regards settings for O2 delivery and patient comfort and lifestyle.
**Results:** Left ventricular end diastolic volume index in CBI correlated with echo-cardiography measurements in both M-Mode (r=0.6181; p<0.002) and B-Mode (Simpson, r=0.6431, p<0.001). Also the Stroke index in CBI correlated with the estimated stroke index in M-Mode (r=0.7077; p<0.001) and B-Mode (Simpson, r=0.7946; p<0.001).

**Conclusions:** In patients with IPAH or CTEPH, cardiac bioimpedance might be a useful non-invasive tool in monitoring left ventricular hemodynamics including left ventricular preload and cardiac output.

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**P2170**

**Relationship between pulse transit time and blood pressure during cardiopulmonary exercise tests**

Thomas Wibmer, Cornelia Kropf, Kathrin Stoiber, Stefan Ruediger, Martin Lanzinger, Wolfgang Rottbauer, Christian Schumann. **Department of Internal Medicine II, University of Ulm Medical Center, Ulm, Baden-Württemberg, Germany**

**Introduction:** Pulse transit time (PTT), the interval between ventricular electrical activity and peripheral pulse wave, is generally assumed to be a surrogate marker for blood pressure changes. Although recent studies have affirmed the potential use of PTT in the diagnostic of sleep disorders and the monitoring of psychophysiological stress, little work has been published on the effect of physical exercise on PTT and results have been inconsistent.

**Aims:** To analyse PTT and its relation to blood pressure during cardiopulmonary exercise tests.

**Methods:** In 20 patients (mean age 51, range 14-82) in a cardiopulmonary unit, ECG and finger-photoplethysmography were continuously recorded during routine cardiopulmonary cycle exercise tests. PTT was calculated for each R-wave in the ECG and the corresponding steepest upstroke in the photoplethysmogram. For each subject the resulting PTT-curve was averaged in order to compensate sample rate- and movement-associated variation, and values were compared to systolic (sBP) and diastolic blood pressure (dBP) in 9 predefined measuring points including measurements at rest, during increasing and maximum exercise as well as during the recovery period.

**Results:** Mean sBP and PTT at rest were 127 mmHg and 372 ms respectively, 197 mmHg and 287 ms under maximum exercise, and 132 mmHg and 365 ms during recovery. All subjects showed a significant, strong negative correlation between PTT and sBP (mean r=-0.97, range -0.99 to -0.93, p<0.0001 to 0.015). The correlation between PTT and dBP with mean r=-0.41 (range -0.87 to 0.76, p=0.035 to 0.83) was rather weak.

**Conclusions:** These results indicate that PTT is a good potential surrogate measure for sBP during exercise.

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**P2171**

**Estimation of the ventilatory compensation point by the minute ventilation and heart rate relationship during exercise at high altitude**

Gabriele Valli1, Paolo Onorati1, Dario Martolini1, Alessandro Ferrazza1, Giuseppe Morici1, Claudio Passino2, Luciano Bernardi3, Daniela Bonardi6, Annalisa Cogo3, Paolo Palange1,1. **Respiratory Pathophysiology, Department of Public Health and Infectious Diseases, University of Rome “La Sapienza”; Rome, Italy; 2Clinical and Experimental Medicine, Section of Respiratory Disease, University of Ferrara, Ferrara, Italy; 3Experimental Medicine, University of Palermo, Palermo, Italy; 4Clinical Physiology, CNR, Pisa, Italy; 5Internal Medicine, University of Pavia, Pavia, Italy; 6Institute of Respiratory Disease, IRCCS, University of Milan, Milan, Italy**

We previously demonstrated that changes in the slope (S) of increment in minute ventilation over heart rate (ΔV′E/ΔHR) can be utilized for the detection of the ventilatory compensation point (VCOP) during incremental exercise at sea level (Slique 360 to 370, ANOVA, p<0.05). A significant difference in the slope of increase in ΔV′E/ΔHR at high altitude (ΔH) was observed both at sea level and high altitude. The ΔV′E/ΔHR slope during cycle ergometer incremental exercise can be used for VCOP detection alternately to the ventilatory equivalents method despite the environmental conditions (hypoxic vs normoxic) which, however, significantly affect the S and VCOP V′E values.

**Introduction:** Both the membrane (Dm) and the capillary (Vc) component of lung diffusion capacity (DLCO) have been shown to be increased in high altitude residents and to remain essentially unchanged in high altitude sojourners. Maximal exercise has been reported to decrease Dm at sea level (Manier 1993). The effects of high altitude exercise on Dm and Vc as evaluated from the DL for carbon monoxide (DLCO) and nitric oxide (DLNO) are incompletely understood.

**Methods:** Lowlanders (n=10) and highlanders (n=14) were tested at 3380m above sea level (Cerro de Pasco, Peru); lowlanders also underwent tests at sea level. Spirometry, alveolar volume (VA), DLCO, DLNO. We hypothesized that the influence of hypoxia on Dm and Vc as evaluated from the DL for carbon monoxide (DLCO) and nitric oxide (DLNO) is incompletely understood.

**Results:** At sea level, lowlanders did not demonstrate alterations in diffusion parameters with respect to pre-endurance test.

**Conclusions:** Sustained exercise in lowlanders resulted in a decrease of DLCO which was probably caused by interstitial lung edema thickening the alveolocapillary membrane, whereas highlanders were capable of maintaining DLCO-levels by an increase in Dm.

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**P2172**

**Lung diffusion at high altitude after endurance exercise in high- and lowlanders**

Maria Overbeck1, Jean-Benot Mariotte2, Claire De Bisschop3, Cristina Scoditti4, Sofia Beloksa5, Herman Groenpophti6,1, Mart Van der Plas6, Francisco Villafuerte7, Jose Luis Macarpu8, Robert Nazir9, Herve Guenard9,1. **Pulmonary Diseases, VU University Medical Center, Amsterdam, Netherlands; 2Department of Pneumology/Respiratory Medicine, St. Elisabeth Hospital Namur, Namur, Belgium; 3Laboratory of Physiologic Adaptations to Physical Activities, Poitiers University, Poitiers, France; 4Department of Fisiopatologia Respiratoria, Università degli Studi, Bari, Italy; 5Department of Physiopathology and Cardiology, Erasme University Hospital-Free University of Brussels, Brussels, Belgium; 6Pulmonary Diseases, Onze Lieve Vrouwe Hospital, Amsterdam, Netherlands; 7Laboratorio di Fisiologia Comparata, Facultà di Scienze e Filosofia, Università di Bari, Bari, Italy; 8Laboratory of Physiologie, Medical Faculty, University of Bordeaux, Bordeaux, France**

**Introduction:** We hypothesized that the influence of hypoxia on Dm and Vc as evaluated from the DL for carbon monoxide (DLCO) and nitric oxide (DLNO) is incompletely understood.

**Methods:** In 20 patients (mean age 51, range 14-82) in a cardiopulmonary unit, we previously demonstrated that changes in the slope (S) of increment in minute ventilation over heart rate (ΔV′E/ΔHR) can be utilized for the detection of the ventilatory compensation point (VCOP) during incremental exercise at sea level (Slique 360 to 370, ANOVA, p<0.05). A significant difference in the slope of increase in ΔV′E/ΔHR at high altitude (ΔH) was observed both at sea level and high altitude. The ΔV′E/ΔHR slope during cycle ergometer incremental exercise can be used for VCOP detection alternately to the ventilatory equivalents method despite the environmental conditions (hypoxic vs normoxic) which, however, significantly affect the S and VCOP V′E values.
P2174
Eucapnic voluntary hyperventilation tests in elite athletes at Centre Hospitalier Universitaire de Montreal
Marc Fortin1, Claude Poirier2.
Eucapnic voluntary hyperventilation (EUVH) tests in athletes have been used for many years to test the ability of athletes to handle an increase in respiratory demands.

Introduction: Since 2001, the International Olympic Committee (IOC) has required athletes to demonstrate exercise-induced bronchospasm (EIB) to be granted the permission to use beta-agonists. EUVH has become the test of choice for the diagnosis of EIB but this test has limited reproducibility.

Objective: The aim of this retrospective study is to describe the population of elite athletes who underwent EUVH at Centre Hospitalier Universitaire de Montreal and to identify factors related to a positive result.

Method: 41 elite athletes underwent EUVH in our institution from 1/1/2009 to 1/5/2010. Positive tests were compared to negative tests. From 1/1/2011 to 1/2/2011 each athlete was sent a questionnaire to gather further information.

Results: 33 EUVH tests were positive. 16/25 (64%) aquatic sport (AS) athletes vs 6/16 (38%) non-AS athletes had a positive test (p=0.10). There were no differences between the positive and negative athletes in mean respiratory rhythm (RR) (66 ± 11 vs 67 ± 9 breath/min, p=0.68), tidal volume (TV) (1.43 ± 0.25 vs 1.62 ± 0.21 l/min, p=0.26), and percentage of target minute ventilation reached (%TMV) (78.9% ± 8.3% vs 90.3% ± 6.0%, p=0.22) but there were significant differences in mean minute ventilation per kilogram of Ventilation (MV/kg) (1.48 l/min/kg vs 1.63 l/min/kg, p=0.04) and age (19.6 ± 2.8 vs 22.8 ± 3.6 yrs, p=0.02).

Conclusion: 54% of elite athletes had a positive EUVH test. AS athletes tended to have more positive tests. Symptoms perceived by athletes had a poor positive predictive value: RR, TV and EUVH were not determinants of EUVH test result but a younger age and lower MV/kg were related to a positive EUVH test.

P2175
Non-invasive estimation of cardiac output by impedance cardiography during incremental exercise in patients with pulmonary arterial hypertension
Eloaura Freireira, Roberta Palchieri Ramos, Pauline Guedes, Daiana Aguiar, Joaquima Sonese, Ota Arakaki, L. Eduardo Nery, J. Alberto Nedner, Medicine, Respiratory Division, Federal University of Sao Paulo, Sao Paulo, SP, Brazil.

Non-invasive monitoring of haemodynamic responses during incremental cardipulmonary exercise testing (CPET) could provide useful information on disease severity and prognosis in pulmonary arterial hypertension (PAH). Using an impedance cardiography (ICG) device that does not require basal impedance or ventricular adjustment, the ICG signal can be estimated directly from impedance cardiography (ICG) device that does not require basal impedance or ventricular adjustment, the ICG signal can be estimated directly from

P2176
The effects of pressure-threshold inspiratory load on lactate clearance after maximal exercise
Michael Johnson1, David Brown2, Katie Bayfield1, Javier Gonzalez2, Dean Mills1, Graham Sharpe1.
1School of Science and Technology, Nottingham Trent University, Nottingham, United Kingdom; 2Division of Nutritional Sciences, University of Nottingham, Nottingham, United Kingdom; 3Department of Gene Therapies, Imperial College London, London, United Kingdom; 4School of Life Sciences, Northumbria University, Newcastle, United Kingdom

Chiappa, G.R. et al. (Med Sci Sports Exerc 2008; 40:1111-16) showed that a 15 cmH2O pressure-threshold inspiratory load accelerated lactate clearance after maximal exercise. However, we observed such an effect only when the relative load of the inspiratory load fell due to a training-induced increase in maximum inspiratory pressure (Brown, P.L. et al. Med Sci Sports Exerc 2010; 42:1110-12).

This study thus tested the hypothesis that lactate clearance is influenced by the magnitude of inspiratory load applied in recovery from maximal exercise.

Eight male participants (VO2max 3.4±0.54L/min) completed four maximal incremental cycling tests (20 W/min starting at 0W), of identical duration (16.2±1.2 min), followed by 20 min recovery comprising either passive recovery (PR) or breathing against an inspiratory pressure-threshold load of either 10 (IPTL10), 15 (IPTL15) or 20 (IPTL20) cmH2O. Arterialised venous blood samples were taken during recovery and analysed for lactate blood concentration ([La]B) every 2 min and blood pH every 4 min. During PR, IPTL10, IPTL15 and IPTL20 the [La]B after 2 min of recovery (11.2±1.9, 11.5±2.6, 11.2±2.0 and 11.2±1.8 mmol/L, respectively), the area under the [La]B curve during recovery (191±48, 192±53, 182±48 and 187±45 mmol, respectively), and mean blood pH (7.27±0.05, 7.28±0.05, 7.28±0.06 and 7.28±0.06, respectively) were not different between trials.

In conclusion, all inspiratory loads failed to influence lactate clearance after maximal exercise. Why inspiratory loading accelerates lactate clearance in some (Chiappa et al.), but not all (present study, Brown et al.), participants is thus unclear and warrants further exploration.

P2177
Heart rate kinetics after exercise in the assessment of autonomic nervous system dysfunction in COPD patients
Anna Barberan1, Alejandro Raimondi2, Diego Agustin Rodriguez1, Gimeno Elena1, Arbiillaga Ana1, Vilaró Jordi1, Roca Josep1, 1Pulmonary Medicine - Pulmonary Function Laboratory, Hospital Clinic i Provincial de Barcelona, Barcelona, Spain; 2Internal Medicine, CEMIC, Buenos Aires, Argentina; 3Epidemiology Department, Centre de Recerca en Epidemiologia Ambiental -CREAL-, Barcelona, Spain

Chronic Obstructive Pulmonary Disease (COPD) patients can develop autonomic nervous system dysfunction (ANSd) during the course of the disease. Although heart rate recovery (HRR) measured immediately after exercise is considered an easy marker to evaluate, the evidence to point to establishment dysfunction remains unclear. Our hypothesis is that the slope of the HRR kinetics after exercise (HRRk) is a simple and useful index to evaluate ANSd in COPD.

HRRk after a constant work rate cycle exercise was recorded before and after 8 weeks of endurance training in 10 COPD patients (FEV1: 47±8%; pred; 71±3 yrs) and 10 healthy controls (66±10 yrs). To calculate HRRk, the heart rate during the recovery period was normalized to range from 1 at the end of the exercise to 0 at the minute 6 of recovery period.

At baseline, the slope of the HRRk was significantly higher in the control group than in the COPD group (p<0.001). Thus, the HRRk at the first minute after exercise was lower in the COPD group (p<0.01) but there were significant differences in mean minute ventilation per kilogram of Ventilation (MV/kg) (1.48 l/min/kg vs 1.63 l/min/kg, p<0.01). After training, the HRRk slope increased in the control group (from 0.009 to 0.012 (p<0.05) but no changes were seen in COPD patients (from 0.007 to 0.008).

We conclude that HRR kinetics after exercise enhances assessment of ANSd in COPD patients.

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P2178
Validation of a compact accelerometer for the measurement of physical activity in patients with COPD
Yoshikai Minakata, Akikudo Sagino, Manabu Nishigai, Masae Kanda, Keichiro Akamatsu, Akira Yamagami, Kazuhiro Hirano, Hirotoshi Sugura, Kazuto Matsunaga, Masakazu Ichinose. Third Department of Internal Medicine, Wakayama Medical University, Wakahama, Japan

Background: The DynaPort Activity Monitor (DAM) has been reported to be useful to evaluate the activity in patients with COPD. However, its battery works for only several hrs and it should be worn at two parts of body. A newly developed compact, single-position triaxial accelerometer (Actimarker) can measure the activity for more than 1 month, but has not been validated for patients with COPD.

Objectives: The validation of the Actimarker in patients with COPD was evaluated and the conditions of day for analysis were determined.

Methods: In study 1, the reproducibility of the Actimarker was evaluated for 14 stable COPD patients by comparing it with DAM. In study 2, the influence of holiday and the weather on the activity was examined. In study 3, the number of measurement days to ensure repeatability was determined.

Results: The differences in the activity by Actimarker and the locomotion by DAM were all within the limit of agreement at the intensity of ≥2.0 METs, ≥2.5 METs and ≥3.0 METs with Bland-Altman Plots. The durations of activity on holidays in patients with jobs and on rainy days were significantly shorter than those on weekdays and on non-rainy days, respectively. The values of intra-class correlation coefficient were more than 0.8 in 3, 4 or 5 days-measurements, and the mean values of duration of activity from 3 or 4 days were all within the limit of agreement with Bland-Altman Plots.

Conclusions: The physical activity assessed by Actimarker was confirmed for its reproducibility and repeatability when the data from 3 non-rainy weekdays were analyzed. Actimarker seems to be useful as a simplified method to evaluate the physical activity in patients with COPD.
P2179
Use of accelerometers for measuring consecutive bouts in physical activity recommendations
Menno J. Zuidema1, Jerine E. Hartman1, Nick H.T. ten Hacken1, Matthieu H.G. de Gree1, Rob C. van Lummel1.1 Research and Development, McRoberts BV, The Hague, Netherlands; 2Pulmonary Department, University Medical Center, University of Groningen, Groningen, Netherlands; 3Institute of Human Movement Sciences, University of Groningen, Groningen, Netherlands

Background: Most recommendations for physical activity (PA) are based on subjective self-reported measures, although performance-based accelerometers are already available for many years. To meet PA recommendations, subjects need to be physically active in bouts varying from 5 to 20 minutes. However, the influence of bout length and bout interruptions in objectively measured PA status is not exactly known.

Aim: The aim of the present study is to investigate the effect of different consecutive bout lengths and bout interruptions on the PA status using accelerometers.

Methods: Twenty COPD patients were selected from a larger dataset, based on a large range in PA level. The DynaPort accelerometer (100Hz, ±2g, McRoberts BV, The Hague, the Netherlands) was used for measuring PA during a full week of daily living. Systematically varied bout lengths and interruptions are investigated to examine PA status.

Results: Bout length of 10 versus 1 minute shows a 71% difference in PA status (91 METs min vs 517 METs min) (figure 1a). Bout interruption duration of 0 vs 5 minutes shows a 57% difference in PA status (91 METs min vs 214 METs min) (figure 1b).

Conclusion: This study shows that varying bout length and interruption duration has large impact on PA status. When applying PA recommendations this should be taken into account, particularly in subjects with a sedentary life style.

P2180
Physiological responses to the incremental shuttle walk test in healthy adults
Victor Dourado1, Ricardo Guerra1, Suzana Tanni2, Leticia Antunes3, Irma Godoy2.1 Department of Health Sciences, Federal University of São Paulo (UNIFESP), Santos, Brazil; 2Department of Internal Medicine, Botucatu Medical School (UNESP), Botucatu, Brazil; 3Rehabilitation Section, Botucatu Medical School (UNESP), Botucatu, Brazil

Physiological responses to the incremental shuttle walk test (ISWT) have been increasingly evaluated in patients. However, previous studies did not include healthy individuals. The aim of this study was to evaluate age- and gender-related changes in physiological responses to the ISWT and to establish predictive equations for such variables. We evaluated 103 non-trained healthy adults (49 males, aged 60±10). After familiarization, ISWT was performed using a telemetric gas analyzer. Physiological responses including oxygen uptake at ventilatory threshold (VO2VT), heart rate (HR) and respiratory (RR) rates, tidal volume (VT), and gas exchange ratio (R) were not affected by sex as well as VO2/HR, RR, and VT were not influenced by age. There were no effect of age and gender in VO2VT (% of peak VO2). Prediction equations adjusted by sex, age, height, weight, LBM, FM, HGS, and ISWT showed R2 values ranging from 0.352 to 0.661 (VO2/VT and VO2/RR respectively). The best predictors of peak VO2 were HGS, weight, FM and age (R2=0.661). Age, weight, height and gender explained 59.7% of Vmax variability. The results therefore might provide a more appropriate frame of reference for normalcy of physiologic responses to the ISWT in healthy older adults. Our results may be useful for better interpretation of walking performance in patients with cardiopulmonary disease.

P2181
Cardiopulmonary exercise testing and hormonal status in winter sports elite athletes
Alexander Ulyanov, Samira Gasymova, Lydia Nikitina, Fedor Petrovskiy. Allergy and Clinical Immunology, Khanty-Mansiysk State Medical Academy, Khanty-Mansiysk, Russian Federation

Background: There are no data available yet regarding relationship between cardiopulmonary exercise testing and hormonal status in athletes.

Methods: A total of 86 elite athletes (48 male and 38 female elite athletes of winter sports (biathlon, ski, ice hockey, snowboard) aged 14-35 were included in the study. Total minute ventilation (V˙E), oxygen uptake (VO2), V˙slope anaerobic threshold (AT) and oxygen pulse (O2/HR) were analyzed (Oxycon Mobile, Vivays). Morning levels of thyroid-stimulating hormone (TSH), free T4 (fT4), cortisol and testosterone were determined using electrochemical immunoassay. Blood samples were taken 7:00 - 8:00 am before exercise.

Results: In contrast to females, males had higher values of V˙E max, AT, VO2 max, O2/HR max and testosterone (p < 0.01 for all comparisons) and lower cortisol (p = 0.03). Males and females had comparable proportions of those who achieved AT during the exercise test (58% and 60% respectively). In athletes who achieved AT, testosterone level was two fold lower compared to those who did not achieved AT (16.2 nmol/l vs 31.8 nmol/l respectively, p = 0.03). We found the following correlations between (i) V˙E max and testosterone (rs=0.59; p<0.01); (ii) VO2 max and testosterone (rs=0.83; p<0.01); (iii) VO2 max and fT4 (rs=0.71; p<0.01); (iv) O2/HR max and fT4 (rs=0.56; p<0.03). Multiple linear regression analysis (forward stepwise) with the inclusion of all studied hormones as independent variables showed that testosterone was the only factor to be significantly associated with V˙E max, AT, VO2 max, O2/HR max in athletes.

Conclusion: The present data suggest a significant role of testosterone in cardiorespiratory fitness in elite athletes.

P2182
Comparison of different O2-delivery systems during exercise in patients with chronic hypoxia
János Juhász2, Julia Juhász2. Internal Medicine, Ilnmatklinik GmbH, Hospital Mainburg, Mainburg, Germany; 2Faculty of Medicine, Christian Albrechts University, Kiel, Germany

Results from case studies using a high-flow oxygen delivery system (TNIP®) suggest advantage regarding the oxygenation compared to conventional O2-therapy (LTOT). Aim of the study was to verify the feasibility, safety and clinical significance of TNIP® compared to LTOT.

Method: 14 patients (pts) with chronic hypoxia underwent standardized treadmill six-minute walk test (6MWTT) in a prospective, randomized study. All pts completed 6MWTT on room air (basal). Then, they underwent consecutive 6MWTTs applying TNIP® and LTOT in a random order (40% of subjective effort). Between 6MWTTs, pts had a rest of 30 minutes. We measured walking distance (m), workload performance (Watt), energy expenditure (kcal), and collected data from Borg-dyspnoea-scale (BDS) and blood gas analysis (BGA) before 6MWTT and at maximum workload (WLm). Primary outcome measures were ΔPaO2 and ΔPaCO2 from rest to WLm and their relation to walking distance (m/Δ1Watt), exercise performance (Watt/Δ1kcal), and energy expenditure (kJ/Δ1Watt).

Results: BDS scores increased from rest to WLm by 5.5±2.15 (basal), 2.67±1.78 (TNIP®) and 3.38±2.04 (LTOT) scores. Walking distances during basal, TNIP® and LTOT were 182.14 m, 235.86 m and 232.86 m respectively. ΔPaO2 and ΔPaCO2 from rest to WLm was higher during LTOT compared to TNIP® (-10.19 mmHg vs. -7.80 mmHg respectively) at identical workload performance (43.21 Watt). Workload economy, performance- and energy efficacy was better during TNIP® vs. LTOT (30.22 vs. 22.85 m/min/Hg; 5.23 vs. 4.24 Watt/min/Hg and 2.02 vs. 1.51 kJ/min/Hg respectively).

Conclusion: TNIP® compared to LTOT was safe to deliver O2 for pts with hypoxia during exercise and superior in regard to workload economy, performance- and energy efficiency.

P2183
The use of submaximal metabolic stress test derived end tidal CO2 may reflect pulmonary hypertension and need for further workup
Mary Lynn Zaremba, Kristin Elliott, Alicia Redford, Syed Ali, Nipurn Shah, Sridhar Reddy. St.Claire Pulmonary & Critical Care, 1210 10th Avenue, Port Huron, MI, United States

There is considerable interest in identifying patients with pulmonary hypertension. In a small pulmonary practice we looked at the use of end tidal CO2 (ETCO2) derived from a quick submaximal stress test and its relevance to pulmonary arterial pressures. Submaximal stress testing is much easier for patients to perform and is being increasingly used in a small office setting. We looked at patients with drops in ETCO2 on exercise and echocardiographic parameters of pulmonary hypertension.

During submaximal metabolic stress testing using Shape non-invasive medical device, breath by breath analysis of air flow, O2 consumption and CO2 production were measured. Patients n=25 with a drop in ETCO2 (n=11) during exercise were compared to patients with a rise in ETCO2 (n=14). Echocardiographic parameters were extracted and used for analysis.
In the group of patients with a drop in ETCO2 there was a significantly higher peak right ventricular systolic pressure (p=0.013477) compared to patients with an increase in ETCO2 during exercise. Submaximal stress testing can be easily performed in the outpatient setting. In patients being evaluated for pulmonary disease and dyspnea, submaximal stress testing may help detect patients that may benefit from further workup of pulmonary hypertension.