EXERCISE PERFORMANCE AND GROWTH STATUS IN EIGHT TO TEN YEAR OLD CHILDREN WITH CYSTIC FIBROSIS

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Keywords: maximum oxygen uptake, pulmonary disease, nutrition

Introduction
Cardiopulmonary exercise performance in individuals with cystic fibrosis (CF) is influenced by both pulmonary and nutritional factors. Pulmonary function may limit exercise performance due to the use of greater minute ventilation to compensate for the increased dead space. Consequently, the ratio of peak minute ventilation to maximal voluntary ventilation often exceeds the normal range of 60% to 70%, limiting mechanical ventilatory reserve. Decreased nutritional status may impair exercise performance through the loss of skeletal muscle mass and changes in the quality of the remaining muscle. Previous studies aimed at identifying the limitations and associated predictors of exercise performance in individuals with CF have found that pulmonary function plays an important role secondary to nutritional status in adolescents and adults with CF. As yet, little or no data exist which has examined the factors that influence cardiopulmonary exercise performance in young, preadolescent children with CF. The purpose of this study was to explore the relationships among growth, nutritional and pulmonary status and exercise performance in a large cohort of preadolescent children with CF and pancreatic insufficiency (PI).

Methods
Children with CF and PI (6.0 to 8.0 yrs) were enrolled from 13 U.S. CF Centers as part of a 2-year study of growth and nutritional status and pulmonary function. Eligibility included an FEV1 > 40% predicted values. Exercise performance was assessed at the 2-year visit. Each subject performed a maximal treadmill or cycle ergometer exercise test. The protocol consisted of 3 minutes of pedaling in an unloaded state followed by a ramp increase in work rate to maximal exercise. Two subjects were exercised using a treadmill protocol. Three minutes of walking was followed by 1-minute incremental ramp increases in speed (m.p.h.) and grade (%) to maximal exercise. The remaining subjects (n=16) exhibited normal responses in cardiopulmonary exercise performance (MVO2=104±17%, PWC=100±20%, BR=24±8%). Overall, growth status was suboptimal (HT-Z= -0.5±1.1, WT-Z= -0.4±1.2, BMI-Z= -0.2±1.1) in the subjects, with normal nutritional status based upon UAC-Z (-0.1±1.2) and UAMA-Z (0.2±1.1). Girls tended (p<0.10) to have lower BMI-Z compared to the boys (-0.4±1.0 vs. 0.1±1.2) and lower UAC-Z (-0.4±1.0 vs. 0.1±1.2). As common in healthy children, BMI was negatively associated with both MVO2 and PWC (r = -.46 and r= -.38, respectively, p<0.01). Using backwards stepwise regression (significance level, p<0.20), and adjusting for age, gender, and BMI, the best positive predictors of MVO2 were FEV1 (p=0.05) and UAMA-Z (p=0.03), with a total R²= .37.

Results
Sixty-five children (ages = 9.3±1.0 years, 33 male) with mild pulmonary disease (FEV1 = 90±14% predicted) were included in this study. The mean values for MVO2 (95±20% predicted) and PWC (97±20% predicted) for the cohort were within normal limits for age- and sex-matched healthy children. VE (81±14% predicted) at peak exercise was lower than normal but did not appear to impact exercise performance (BR = 22±8.2). Girls differed significantly from boys in VE (77±13% vs. 86±13%, respectively, p=0.007), but not in MVO2, (94±20% vs. 96±20%, respectively, p>0.20) or PWC (94±17% vs. 99±20%, respectively). Further examination revealed five distinct groups emerged from the data. Low MVO2 (71±15%), low PWC (82±10%), and anaerobic threshold (AT) data (70±11% of peak MVO2) suggested musculoskeletal de-conditioning in 5 subjects. Eight subjects exhibited mildly reduced MVO2 (76±9%), normal PWC (91±14%), normal FEV1, and FVC (102±8%, 97±10%), and normal BR (24±6%). Low BR (8±4%) were present in 28 subjects without significant impact on MVO2 (107±12%) or PWC (103±18%). Pulmonary abnormalities (FEV1=74±8%, BR=8±4%) were present in 8 subjects which appeared to impact exercise performance (MVO2=68±9%, PWC=80±17%). The remaining subjects (n=16) exhibited normal responses in cardiopulmonary exercise performance (MVO2=104±17%, PWC=100±20%, BR=24±8%). Overall, growth status was suboptimal (HT-Z= -0.5±1.1, WT-Z= -0.4±1.2, BMI-Z= -0.2±1.1) in the subjects, with normal nutritional status based upon UAC-Z (-0.1±1.2) and UAMA-Z (0.2±1.1). Girls tended (p<0.10) to have lower BMI-Z compared to the boys (-0.4±1.0 vs. 0.1±1.2) and lower UAC-Z (-0.4±1.0 vs. 0.1±1.2). As common in healthy children, BMI was negatively associated with both MVO2 and PWC (r = -.46 and r= -.38, respectively, p<0.01). Using backwards stepwise regression (significance level, p<0.20), and adjusting for age, gender, and BMI, the best positive predictors of MVO2 were FEV1 (p=0.05) and UAMA-Z (p=0.03), with a total R²= .37.

Table 1: Characteristics of Study Population (mean±S.D.) (*p<0.10).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Male (n=33)</th>
<th>Female (n=32)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yrs)</td>
<td>9.2±0.9</td>
<td>9.3±1.0</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>132±7</td>
<td>132±9</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>30±8</td>
<td>29±8</td>
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<tr>
<td>BMI-Z</td>
<td>0.1±1.2</td>
<td>-0.4±1.0*</td>
</tr>
<tr>
<td>UAMA-Z</td>
<td>0.02±1.1</td>
<td>0.01±1.1</td>
</tr>
<tr>
<td>UAC-Z</td>
<td>-0.12±1.2</td>
<td>-0.08±1.1</td>
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<tr>
<td>UAMA-Z</td>
<td>-0.20±1.1</td>
<td>-0.33±1.1</td>
</tr>
<tr>
<td>FEV1 (% predicted)</td>
<td>91±14</td>
<td>91±16</td>
</tr>
<tr>
<td>PWC (% predicted)</td>
<td>103±16</td>
<td>96±13</td>
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</table>

Table 2: Exercise Parameters at Peak Exercise (mean±S.D.) (*p<0.007).

<table>
<thead>
<tr>
<th>Variable</th>
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<th>Female (n=32)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VO2 (% predicted)</td>
<td>96±20</td>
<td>94±20</td>
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<tr>
<td>VE (% predicted)</td>
<td>86±13</td>
<td>77±13*</td>
</tr>
<tr>
<td>HR (% predicted)</td>
<td>91±5</td>
<td>92±5</td>
</tr>
<tr>
<td>PWC (% predicted)</td>
<td>98±20</td>
<td>94±17</td>
</tr>
<tr>
<td>SoA (%)</td>
<td>99±2</td>
<td>99±3</td>
</tr>
<tr>
<td>RER</td>
<td>1.12±0.1</td>
<td>1.14±0.1</td>
</tr>
<tr>
<td>BR (%)</td>
<td>24±8</td>
<td>20±12</td>
</tr>
</tbody>
</table>
Discussion

Data from this study represent a comprehensive analysis of the overall exercise performance and factors that predict performance in young children with CF and PI. Similar to previous studies in adolescents and young adults, this data indicate that exercise performance in CF is determined by the degree of underlying pulmonary disease, nutritional status, growth status, or a combination of these factors. However, wide ranges of age have limited previous study’s ability to make conclusions specific to age and identify the presence of any sub-groups identified in this study. Data from this study demonstrate that overall performance during exercise was normal in this sample of preadolescent children with CF and PI. Overall, growth status was sub-optimal, and nutritional status was sub-optimal in girls. After adjusting for confounding variables, both pulmonary function and lean body mass positively and significantly predicted exercise performance. Patients with chronic lung disease can be limited by their ventilatory capacity. Peak VE during aerobic exercise in subjects with chronic lung disease is usually very close to maximal voluntary ventilation, suggesting that they have little or no breathing reserve. In this group of young children with CF and PI the lower VE (and subsequent low BR) noted at peak exercise did not appear to significantly impact exercise performance. This may be explained by the cohort’s relatively mild underlying pulmonary disease.

Although the cohort as a whole exhibited normal indices of cardiopulmonary exercise performance, there appears to be a number of sub-groups that display varied responses to cardiopulmonary exercise performance. Underlying pulmonary disease and nutritional status impacted overall exercise performance in eight of the subjects, whereas, in the remaining subjects \( n=57 \) underlying disease had little or no effect at this point to impact exercise performance. These findings indicate the importance of routine evaluations of cardiopulmonary exercise performance, growth and nutritional status, and pulmonary function young children with CF to assess disease severity and changes in the cardiorespiratory responses to exercise that occur with disease progression into adolescence and adulthood.

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OXYGEN UPTAKE KINETICS ARE SLOWED IN CYSTIC FIBROSIS

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Keywords: oxygen uptake, cystic fibrosis, kinetics

There are conflicting reports on the kinetics of oxygen uptake at the onset of exercise in patients with cystic fibrosis (CF). The objective of the present study was, therefore, to compare oxygen uptake \( (V\text{O}_2) \) kinetics in CF-patients to those of healthy controls (CON). 18 CF-patients \( (\text{FEV1} 37\text{-}98\%\text{predicted}) \) and 15 CON aged 10 to 33 years completed 2-4 transitions from low intensity cycling \( (\text{stage} 1\text{-}20 \text{W}) \) to cycling at 1.3-1.4 W/kg body weight \( (\text{stage} 2) \) in a semi-supine position. There was no difference between groups in heart rate at stages 1 and 2 or in relative exercise intensity, as expressed as \%V\text{O}_2\text{peak} \text{or percentage of ventilatory threshold.} \ V\text{O}_2\text{data of stages 1 and 2 were interpolated second-by-second, time-aligned, and averaged. Mono-exponential equations were used to describe phase II VO2-responses. While there was no difference between CF and CON in time delay (16.6±5.5 vs. 19.6±5.5 s) or amplitude (11.0±1.7 vs. 10.2±1.6 ml/W) of phase II VO2-response, time constant tau was significantly prolonged in CF compared with CON \((37.3±12.5 vs. 25.6±8.7 \text{s})\). Multiple linear regression analysis using the combined data of CF-patients and healthy controls identified oxygen saturation at peak exercise and time delay of the phase II VO2-response as significant independent predictors of tau \((R^2=0.69)\). When tau was adjusted for the effects of these two variables, the difference between CF patients and controls disappeared. In conclusion, \( V\text{O}_2\)-kinetics are slowed in CF which may, in part, be attributed to an impairment of oxygen delivery.

Figure 1: Comparison of Peak Oxygen Uptake and Upper Arm Muscle Area.

SHORT-TERM EFFECT OF DIFFERENT SPORT ACTIVITIES AND PHYSIOTHERAPY ON SPUTUM PRODUCTION AND LUNG FUNCTION IN YOUNG PATIENTS WITH CYSTIC FIBROSIS

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Keywords: cystic fibrosis, physical activity, sputum production

Physical activity and physiotherapy are important elements in the daily treatment of young patients with cystic fibrosis. One positive effect is the increase in mucus expectorations which might lead to an improved lung function and oxygen saturation. It is, however, not clear which type of physical activity is especially helpful. The aim of the study was therefore, to determine the effect of a combined sport-physiotherapy program, using either trampoline or bicycle, on the sputum production, oxygen saturation and short-term lung function in adolescents and young adults with cystic fibrosis.

Twelve 15- to 30-year-old cystic fibrosis patients took part in the study. They were randomly allocated into 3 groups. Each subject performed all test protocols on 3 non-consecutive days of a week. The bicycle and trampoline protocol included 30
minutes of the activity at a heart rate of 140-160 bpm, the third group played billiard over 30 minutes. All sessions were followed by a physiotherapy program. A 30 min break followed the sport and physiotherapy program. Before, after the sport activity including a 30 min break, and after the physiotherapy including a 30 min break, a pulmonary function was performed and the sputum production evaluated. Transcutaneous oxygen saturation was measured initially and at the end of the combined sport-physiotherapy program. The sputum production during trampoline was significantly higher than after billiard, but it was not different with bicycling compared to the others. Sport (trampoline and biking) was equally effective in sputum production than the following physiotherapy; billiard was significantly less effective in sputum production than the follow-up physiotherapy. Neither sport nor physiotherapy had a significant effect on the lung function. The transcutaneous oxygen saturation increased significantly after the combined bicycle-physiotherapy and trampoline-physiotherapy program but did not change after the billiard-physiotherapy program. Trampoline was the preferred activity of all participants. A daily physical activity and physiotherapy of 30 min have an equal, but additive effect on the sputum production in adolescents and young adults with cystic fibrosis. In combination, they lead to an improved oxygen saturation. The type of sport does not seem to play a role.

AIRWAY OBSTRUCTION IS AN UNCOMMON CAUSE OF EXERCISE-LIMITING SYMPTOMS IN PEDIATRIC PATIENTS WHO DO NOT HAVE HISTORICAL FEATURES OF ASTHMA

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Keywords: exercise, asthma, stress testing

Introduction

Exercise intolerance and/or exercise-limiting chest symptoms are common complaints in pediatric patients who often result in medical referral. Several studies suggest that airway obstruction is a common cause of exercise-limiting symptoms, even in patients who do not have historical features of asthma.\(^1\) Based on these studies and a prevalent concern regarding the underdiagnosis of asthma, it has become common practice to prescribe asthma medications to pediatric patients with exercise-limiting symptoms and assess symptom responsiveness as a means of ruling in/out airway obstruction. The goal of this study was to determine the incidence of airway obstruction as a cause of exercise-limiting symptoms in children and adolescents without historical features of asthma.

Methods

294 pediatric patients were referred to our pediatric cardiopulmonary laboratory for evaluation of exercise-limiting symptoms including exercise intolerance, excessive dyspnea, chest discomfort, cough, or 2 or more symptoms in combination. Patients were screened by questionnaire for historical features suggestive of underlying airway disease (asthma diagnosed in past by medical provider, previous wheezing episodes, 2 or more episodes of bronchitis and/or pneumonia, recurrent and prolonged cough, frequent nighttime symptoms).\(^4\) Of the 294 patients screened, 120 (41% of total) answered no to all screening questions and comprise the study population. Patients had baseline spirometry performed and then underwent treadmill stress testing with a rapidly progressive workload aiming to reach heart rate >170 bpm within 2 minutes of starting and then maintain that workload until unable to continue because of symptoms or exhaustion. Spirometry was repeated 3, 6, and 10 minutes after completion of exercise. Exercise induced bronchospasm (EIB) was defined as >10% fall in forced expiratory volume in 1 second (FEV\(_1\)) or >20% fall in forced expiratory flow 25-75% (FEF 25-75%) post exercise.\(^5\)

Results

One patient was unable to perform spirometry. In the remaining 119 patients comprising the study group, age ranged from 6-18 years (mean 12 years), and there were 57 males and 62 females. Twenty seven study patients (23%) were on or had recently been treated with asthma medications. Of the 119 patients, 8 (6.7%) had airway obstruction identified—3 patients had abnormal spirometry values and flow/volume curves at baseline that did not worsen after exercise but corrected after nebulized albuterol, and 5 patients met diagnostic criteria for EIB. Ninety one patients (76%) had their presenting symptoms reproduced during stress testing. In these 91 patients, 6 (6.6%) had airway obstruction identified. Alternate diagnoses were made or suspected in 69 of the 111 patients (62%) without identifiable airway obstruction including poor fitness (31), poor breathing technique or hyperventilation (20), costochondritis (15), vocal cord dysfunction (1), vasovagal response (1), sensing appropriate sinus tachycardia (1).

Conclusions

1. In pediatric patients without historical features of asthma, airway obstruction is an uncommon cause of exercise-limiting symptoms;
2. In this patient population, asthma medications should not be prescribed without first confirming the diagnosis of asthma;
3. Using a progressive treadmill protocol, symptoms can be reproduced in a majority of patients, and alternate diagnoses can be made or suspected in a high percentage.

References

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EXERCISE INDUCED STRIDOR — VISUALISING THE PROBLEM

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Keywords: exercise induced asthma, vocal cord dysfunction, exercise induced laryngeal dysfunction

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Exercise induced asthma (EIA) is characterised by breathing difficulties and wheeze subsequent to physical activity. Vocal cord dysfunction (VCD) and exercise-induced laryngomalacia (EIL) are characterised by shortness of breath, stridor, chest pain and occasionally immense fear occurring during exercise. Both entities may mimic EIA. Misdiagnosed EIA should be avoided to prevent potentially harmful and unnecessary medication. In our experience, exercise induced stridor is more prevalent than previously reported. Despite extensive diagnostic work-up, however, upper airway pathology was only infrequently verified in our patients. To improve patients work-up, a standardised diagnostic program including a questionnaire, clinical examination, spirometry, metacholine provocation, a classification system for laryngeal pathology and videorecorded transnasal flexible laryngoscopy during exercise, was developed. Fifteen non-symptomatic, healthy controls and 40 children and adolescents experiencing stridor during exercise testing, were studied. Laryngoscopy with simultaneous videotaping was performed while subjects were running to exhaustion. Parameters of gas exchange, exercise flow volume loops and clinical data such as breath sounds and other signs of stridor were continuously recorded. Every control subject had normal laryngeal function at rest, during and after exercising. Abnormalities were demonstrated in the majority of symptomatic subjects. A variety of laryngeal pathology, ranging from mere vocal cord dysfunction to obviously enlarged aryepiglottic folds and combinations of the two, were recognised. Medial motion of the dorsal part of the aryepiglottic folds was the most frequent finding. Exercise induced stridor in children and adolescents admitted for EIA test rather than particular flow volume patterns and/or metacholine response, predicted positive laryngoscopy. Conclusions: Exercise induced laryngeal dysfunction (ELD) is not uncommon in subjects complaining of exercise induced respiratory symptoms. Exercise testing to complete exhaustion or until presentation of symptoms under close observation of respiratory pattern, is highly recommended. If inspiratory stridor occurs, transnasal flexible laryngoscopy (ETNL) during exercise should be performed. A detailed presentation of the method and specific findings of normal and dysfunctional upper airways will be presented.

### CARDIOPULMONARY EXERCISE RESPONSES IN CHILDREN AT ALTITUDE AND SEA LEVEL

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**Keywords:** altitude, exercise, children

**Introduction**

The effect of altitude on aerobic capacity in adults has been well studied. There is a lack of data regarding the effect of altitude on cardiopulmonary exercise performance in children. In addition, the majority of altitude research is performed at extreme altitude (greater than 10,000 feet). We sought to compare exercise performance in a group of healthy age and gender matched children at sea level (SEA) and moderate altitude (ALT; 5280 feet).

Exercise during altitude can be commonly described as hypoxia, which leads to increased heart rate, reduced systolic blood pressure, increased oxygen consumption, and reduced systemic vascular resistance. These changes may be accompanied by decreased exercise performance, increased ventilation volumes, and reduced ventilatory efficiency. The decrease in exercise performance at the higher altitude is usually minimal, however, exercise performance decreases in a manner that is proportional to the degree of hypoxia experienced.

**Methods**

Healthy children ages 8-17 years free from cardiopulmonary disease were recruited for the current study. Maximal symptom limited exercise was performed using a cycle ergometer and a Sensormedics metabolic cart. Forty-two children at ALT formed the study group and were compared to a population of 171 children at SEA. Appropriate institutional review and approval was given from the University of Arkansas Children’s Hospital and the Denver Children’s Hospital. All subjects and their parents signed written informed consent. Data was analyzed using non-paired t-tests and is presented below as mean +/- SD.

**Results**

Subject demographics are presented in Table 1. There were no differences in age (13.61 +/- 2.6 vs. 14.08 +/- 2.6 yrs; p=0.584), gender (57 vs. 56 % males; p=0.942), height (162.16 +/- 15.9 cm vs. 164.82 +/- 15.0 cm; p=0.334) or weight (57.54 +/- 17.3 kg vs. 54.76 +/- 14.4 kg; p=0.334) between subject groups. Significant differences were noted in several cardiovascular parameters and are presented in Table 2. Children at ALT had a lower absolute peak oxygen consumption (2.39 +/- 0.9 vs. 1.99 +/- 0.7 L/min; p=0.02) and when the oxygen consumption was corrected for body weight (40.98 +/- 8.3 vs. 36.40 +/- 7.8 ml/kg/min; p=0.001). Children at ALT further demonstrated a reduced oxygen pulse (12.49 +/- 4.8 vs. 10.81 +/- 3.6 ml/min/beat; p=0.04) and a reduced rise in oxygen pulse slope (0.93 +/- 0.4 vs. 0.67 +/- 0.2; p<0.001). Greater ventilatory inefficiency, as evidenced by a greater ΔVE/ΔVO2, was seen in children at ALT when compared to children at SEA (16.16 +/- 4.3 vs. 10.9 +/- 4.4 ml/min/beat; p<0.001). However, there were no differences in ΔVE/ΔVO2 (40.4 +/- 7.1 vs. 40.9 +/- 6.8; p=0.658) between subject groups. There was no differences in peak heart rate (191.9 +/- 11.1 vs. 192.6 +/- 11.9 bpm; p=0.747) and peak ventilation (85.6 +/- 20.9 vs. 94.3 +/- 31.2 L/min; p=0.103) between subject groups.

**Table 1. Demographic Variables for Subjects**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Sea Level (n=172)</th>
<th>Altitude (n=42)</th>
<th>p value</th>
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<tr>
<td>Age (years)</td>
<td>13.61 +/- 2.6</td>
<td>14.08 +/- 2.6</td>
<td>0.584</td>
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<tr>
<td>Height (cm)</td>
<td>162.16 +/- 15.9</td>
<td>164.82 +/- 15.0</td>
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<tr>
<td>Weight (kg)</td>
<td>57.54 +/- 17.3</td>
<td>54.76 +/- 14.4</td>
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<td>BSA (m²)</td>
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<td>1.59 +/- 0.3</td>
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<td>BMI (kg/m²)</td>
<td>21.38 +/- 4.1</td>
<td>19.79 +/- 2.7</td>
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**Table 2. Cardiopulmonary Exercise Data for Subjects**

<table>
<thead>
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<th>Variable</th>
<th>Sea Level (n=172)</th>
<th>Altitude (n=42)</th>
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<tr>
<td>VO₂ (ml/kg/min)</td>
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<td>VE (L/min)</td>
<td>94.29 +/- 31.2</td>
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<td>0.103</td>
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<tr>
<td>ΔVE / ΔVO₂ slope</td>
<td>40.95 +/- 6.8</td>
<td>40.41 +/- 7.1</td>
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<tr>
<td>ΔVE / ΔVO₂ slope</td>
<td>29.64 +/- 4.3</td>
<td>33.86 +/- 7.4</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>
Introduction
Rapidly increasing rates of obesity and type 2 diabetes mellitus have encouraged increased interest in the role of lifestyle in the development of CVD. The preventive effect of physical activity is thought to operating through modification of the biological risk factors for such disorders, including hypertension, hyperinsulinaemia, elevated serum total cholesterol and triglyceride levels, low HDL-cholesterol and glucose intolerance. Clustering of these risk factors in obese individuals (the metabolic syndrome) has been described in both children and adults. In children many studies have investigated the relationship between physical activity, physical fitness and CVD risk factors. In some studies a weak relationship between physical activity or fitness and the risk factors of the metabolic syndrome has been described, and interpreted as lack of evidence for the preventive effect of physical activity in relation to CVD (1).
However, it may be more logical to evaluate the level of risk and the association between the level of risk and lifestyle in relation to clustering of risk factors instead of levels in single risk factors in children. It is important to better understand this relationship, since if the roots of CVD are laid down in childhood, lifestyle modification during childhood and adolescence may be effective in lowering CVD risk in later life.

Methods
The study was carried out as a cross sectional study of 1020 randomly selected children 9 and 15 years of age. Physical measurements were blood pressure (BP), sum of four skinfolds and cardiorespiratory fitness. Biochemical measurements were serum total cholesterol (TC), high density lipoprotein cholesterol (HDL), triglyceride, glucose and insulin. Cardiorespiratory fitness was assessed by a maximal cycle ergometer test. A subject was defined as having a risk factor if he/she belonged to the upper quartile of risk within age and gender group for that risk factor. Clustering was analysed in relation to being at risk in a) three or more and b) four or more of five possible risk factors (TC:HDL ratio, insulin:glucose ratio, triglyceride, systolic BP and sum of four skinfolds).

All analyses were performed using the Statistical Package for the Social Sciences (SPSS) version 11.

Results
Physical fitness was weakly related to single CVD risk factors except sum of skinfolds where the relationship was strong. Low fitness increased the risk of having three or more CVD risk factors. Compared to children in the most fit quartile, the subsequent quartiles had odds ratios (OR’s) of 3.6 (95% CI: 0.7-17.4), 3.6 (95% CI: 0.7-17.7) and 24.1 (95% CI: 5.7-101.1). Four or five risk factors were observed to be extremely rare among children in the high fit quartile - only two subjects in this quartile had 4 or more risk factors. Therefore, in order to obtain smaller confidence intervals, the analysis were repeated defining cases as those children having three or more risk factors. In this analysis, the odds ratios, using the upper quartile of fitness as reference, were 1.9 (95% CI: 0.8-4.1), 3.0 (95% CI: 1.4-6.3) and 11.4 (95% CI: 5.7-22.9) respectively, with OR using the upper quartile of fitness as reference of 1.9 (95% CI: 0.8-4.1), 3.0 (95% CI: 1.4-6.3) and 11.4 (95% CI: 5.7-22.9), respectively. Using the criterion of four or more risk factors, an OR of 24.1 (95% CI 5.7 – 101.1) was found.

Keywords: CVD risk factors, children, physical fitness

Conclusion
In summary, children at moderate altitude have impaired aerobic capacity associated with impaired ventilatory efficiency when compared to healthy controls at sea level. The increased ∆VE/∆VCO₂ at altitude may reflect an altered set point for pCO₂.

CLUSTERING OF RISK FACTORS IN CHILDREN

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Discussion/Conclusion

The main strength of this study is the large number of randomly sampled children, who are representative of the general Danish population for these ages. The sample size makes it possible to analyse clustering of risk factors, which is present in a small proportion of the population. This study of children and adolescents confirms the findings from studies on adults that physical fitness is associated with individual CVD risk factors, but associations are weak except for the relationship with fitness, which is strong. Further, CVD risk factors cluster strongly in individuals with low fitness. The rationale for selecting the five risk factors reported above to assess clustering was that they are all recognised elements of the metabolic syndrome. It is plausible that insulin insensitivity may be the common aetiology causing these risk factors to cluster (2).

It is noteworthy that the association between physical fitness and clustering of risk factors in our study is even stronger than the association between fitness and CVD mortality in adults. It should also be noted that the physical fitness level of the children and adolescents in the lowest quartile of fitness was as low as the fitness levels of blind children and adolescents, who because of their handicap engage in very little vigorous physical activity.

Because individual risk factors track from childhood into adulthood, the childhood period should be considered a vital period for primary CVD prevention programmes, of which the promotion of physical fitness should be an important element.

References


THE RELATIONSHIP BETWEEN PHYSICAL ACTIVITY AND DIETARY INTAKE DURING ADOLESCENCE AND ARTERIAL PROPERTIES AT THE AGE OF 36 YEARS

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Keywords: physical activity, dietary intake, arterial properties

Introduction

One of the most important chronic diseases in the developed countries is cardiovascular disease (CVD). Even though the clinical symptoms of CVD do not become apparent until much later in life, it is known that the origin of CVD lies in early childhood. It is therefore often argued that prevention of CVD has to start as early in life as possible. A possible preventive strategy with respect to the prevention of CVD at adult age could be a change towards a healthy lifestyle during youth. Physical activity and dietary intake are recognised as important components of such a healthy lifestyle. For these components, especially the adolescent period seems to be important.

However, little is known to what extent adolescent lifestyle is related to arterial wall thickness and stiffness, i.e. two major contributory factors to cardiovascular morbidity and mortality. The purpose of this study was to investigate the relationship between physical activity and dietary intake during adolescence and wall thickness of the carotid and stiffness of the carotid and the femoral artery later in life, i.e. at the age of 36 years.

Methods

In the Amsterdam Growth and Health Longitudinal Study (AGHLS), over a period of 25 years, nine repeated measurements were carried out. During the first four years of the study (starting at 12/13 years of age) four consecutive measurements were carried out. Between the age of 21 and 32 years four measurements were performed, and in 2000 the subjects were measured for the ninth time at the age of 36 years. Physical activity was measured by an extensive interview and expressed in METs. The total activity score was calculated by using duration, intensity and frequency of all physical activities performed one month prior to the interview. Dietary intake was measured by a cross-check dietary history over the last three months prior to the measurement. In the analyses a so-called ‘dietary health score’ was used in which the intake of fruits, vegetables, fish and low-fat dairy products were valued positively and in which the intake of meat and snacks was valued negatively. The dietary ‘health score’ ranged between 0 (indicating that the subject was in none of the ‘healthy’ tertiles for all food groups) to 6 (indicating that the subject was in the ‘healthy’ tertile for all food groups). Both physical activity and dietary intake were measured 3 to 4 times during the adolescent period (i.e. between 12 and 16 years of age) and the average was used in the analyses. Regarding the arterial properties measured at 36 years of age, for both the carotid and the femoral artery, compliance and distensibility of the vessel wall were measured using ultrasound. For the carotid artery also intima media thickness and Young’s elastic modulus were measured (also with ultrasound). Linear regression analyses were used to analyse the relationships and the analyses were performed on a population of 75 males and 79 females.

Results

The results of the linear regression analyses are shown in Table 1:

<table>
<thead>
<tr>
<th>Physical activity</th>
<th>Diet health score</th>
</tr>
</thead>
<tbody>
<tr>
<td>males</td>
<td>females</td>
</tr>
<tr>
<td>compliance</td>
<td>-0.06 (p=0.39)</td>
</tr>
<tr>
<td>density</td>
<td>-0.05 (p=0.41)</td>
</tr>
<tr>
<td>Young’s elastic modulus</td>
<td>-0.07 (p=0.56)</td>
</tr>
</tbody>
</table>

Table 1: Standardised regression coefficient and p-values of the linear regression analyses regarding the relationship between physical activity and dietary intake during adolescence and thickness and stiffness of the carotid and femoral artery.
Results of the analyses showed that physical activity during adolescence was not associated to large arterial properties at the age of 36 years. On the other hand, for males, a ‘healthy diet’ during adolescence was associated to healthy distensibility and compliance of the carotid artery (standardisation regression coefficients 0.35 [p<0.01] and 0.29 [p<0.01] respectively). Besides this, for males also an inverse relationship was found with Young’s elastic modulus (standardisation regression coefficient -0.27 [p<0.02]). For females and with arterial properties of the femoral artery no significant associations were found (besides the unexpected inverse relationship between a ‘healthy diet’ and distensibility of the femoral artery for females).

Discussion/Conclusion
It can be concluded that for males a ‘healthy diet’ during adolescence was related to ‘healthy’ arterial properties of the carotid artery at adult age. Physical activity during adolescence was not related to large arterial properties at adult age.

References

BLOOD PRESSURE MEASUREMENT DURING TREADMILL EXERCISE — A CHALLENGE

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Keywords: oxygen consumption, anaerobic threshold, repeatability

Introduction
Exercise testing is valuable to determine the adequacy of cardiac and pulmonary function. This kind of physiological stress can both determine exercise capacity, and elicit exercise limitating cardiovascular abnormalities or pulmonary diseases. At “The Heart and Lung Laboratory” Department of Paediatrics, Haukeland University Hospital, we use treadmill testing to reveal exercise limiting disease and to monitor patients over time. When monitoring patients it is important to evaluate the results by parameters that are reproducible. The test to test variation must also be considered. By examining blood pressure, heart rate and oxygen consumption, we can follow changes due to illness. Maximal oxygen consumption (VO2max) is a highly reproducible parameter. It depends almost exclusively on the cardiovascular system. Oxygen consumption during sub-maximal exercise on ergometer cycle is less reproducible than at maximal exercise (Wergel-Kolmert et al. 2002). Even though anaerobic threshold is measured at one point, we know that transition from aerobic to anaerobic work is gradual. In an incremental exercise test there will be two ventilatory breakpoints, between which there is a gradual transition from aerobic to anaerobic activity, also called isocapnic buffer phase (Wasserman et al. 1994). The phase after the second ventilatory breakpoint is called hypocapnic hyperventilation, since hyperventilation leads to low expiratory concentrations of CO2.

According to this we can divide an incrementing exercise test into aerobic phase, isocapnic buffer phase and hypocapnic hyperventilation phase. When examining oxygen consumption in each phase, we find differences due to exercise status or disease. Repeatability for these phases has not been evaluated. Blood pressure during exercise can reveal exercise induced hypertension or blood pressure fall, which can indicate or confrim exercise limiting heart or lung disease. By following blood pressure through an incrementing treadmill test, we can study each patient's ability to perform physical activity. Systolic blood pressure rises with increasing activity as a result of increasing cardiac output, whereas diastolic pressure usually remains about the same or is moderately reduced (Fletcher et al. 2001). Association for the Advancement of Medical Instrumentation and British Hypertension Society have prepared guidelines for standardising devices to measure blood pressure during resting conditions. However, there are no standards for blood pressure measurements during exercise. We studied repeatability of automated sphygmomanometry during treadmill exercise for better understanding of how to interpret blood pressure readings during exercise.

Methods
Ten healthy and non-smoking men (age: 26.1 ± 3.6 yrs, height: 179.6 ± 6.4 cm, weight: 76.6 ± 9.7 kg) were studied over a period of 2 months. Informed consent was obtained from all participants. Our study complies with Norwegian laws. The Regional Ethical Committee has approved the project. Each subject performed two identical exercise test on a treadmill (Woodway Ergo ELG 70, Weil am Rhein, Germany), according to a modified Bruce protocol. The two tests were to be separated by minimum 48 hours and maximum 2 weeks, and were done at the same time of the day. The subjects did not eat or drink coffee the last twelve hours before each test. A Medical Graphics cardiopulmonary exercise system (Sensormedics V-max29, Yorba Linda, Savi Ranch Parkway, CA) was used, and expired gas was sampled through a Rudolph mask. The expiratory gas was collected and conveyed to a spirometer and to oxygen and carbon dioxide detectors. The measurement system was carefully calibrated, in accordance to the Sensormedics’ standard, daily and before each test. The oxygen consumption, carbon dioxide (CO2) production and ventilation were measured continuously breath-by-breath. Mean respiratory values of 30 seconds were used in all calculations. Serum lactate concentration was measured (Laktate pro, Arkray, Shiga, Japan) every 90 seconds. Blood pressure in the right arm was measured before, after and at 4 minutes intervals during the exercise test (Paramed Technology Inc. Model 9350 Blood Pressure Monitor). The blood pressure monitor uses an automated pressure cuff with pressure sensor. Heart rate and ECG were registered by “Sensormedics” 12 lead system, and “Polar Accurex Plus Sport-tester” (Finland) was used to confirm heart rate. VO2max was defined as the highest oxygen consumption measured during exercise. We assumed that VO2max was achieved when two of the four following criteria were met: subjectively felt exhaustion, the presence of an oxygen consumption plateau despite increasing exercise intensity, attainment of 95% of the age-predicted maximal heart rate and a respiratory exchange ratio equal to or greater than 1.05, during the final increment of the exercise test. Ventilatory anaerobic threshold is defined as the oxygen consumption at anaerobic threshhold.
threshold defined by the v-slope method (Beaver et al. 1986). Lactic acid threshold is defined as the oxygen consumption when blood lactate concentration increased above baseline level. The onset of blood lactic acid accumulation is defined as the oxygen consumption when lactic acid concentration reached 4 mmol/liter. Onset of isocapnic buffering (Wasserman et al. 1994) was oxygen consumption when end tidal oxygen pressure and ventilatory oxygen equivalent (ventilation/oxygen consumption) began to increase and indicated the first ventilatory breakpoint. The onset of hypocapnic hyperventilation (Wasserman et al. 1994) is defined as the oxygen consumption when end tidal CO2 pressure began to decrease and ventilatory CO2 equivalent (ventilation/CO2 production) began to increase and indicated the second ventilatory breakpoint. Aerobie phase is defined as the oxygen consumption between zero and onset of isocapnic buffering. Isocapnic buffer phase is the oxygen consumption between onset of isocapnic buffering and onset of hypocapnic hyperventilation. Hypocapnic hyperventilation phase is the oxygen consumption between onset of hypocapnic hyperventilation and VO2max. All data are expressed as means ±SD unless otherwise indicated. Repeatability between two measurements was evaluated by the coefficient of repeatability (COR), calculated as 2 SD of the difference between the two measurements and expressed as a percentage of the measurements' mean (COR% = 2 SD/mean). Spearman’s rank correlation coefficient (r) was used to study the relation between VO2max and sub-maximal values. A standard two-sided t-test for comparison of two groups of data with different standard deviations is used to describe significance. A p-value < 0.05 was considered statistically significant.

**Results**

VO2max (test1: 56±10 ml·kg⁻¹·min⁻¹, test2: 57±10 ml·kg⁻¹·min⁻¹) has excellent repeatability (COR% = 8.5). Ventilatory anaerobic threshold (test1: 31±8 ml·kg⁻¹·min⁻¹, test2: 31±7 ml·kg⁻¹·min⁻¹) is achieved just before lactic acid threshold (test1: 33±6 ml·kg⁻¹·min⁻¹, test2: 36±6 ml·kg⁻¹·min⁻¹) and approximately in the middle of the isocapnic buffer phase. Repeatability for ventilatory anaerobic threshold (COR% = 11.0) is better than for lactic acid threshold (COR% = 32.0). Onset of blood lactic acid accumulation (test1: 40±7 ml·kg⁻¹·min⁻¹, test2: 46±10 ml·kg⁻¹·min⁻¹) seems to express onset of hypocapnic hyperventilation (test1: 44±8 ml·kg⁻¹·min⁻¹, test2: 44±8 ml·kg⁻¹·min⁻¹). Repeatability for oxygen consumption at onset of blood lactic acid accumulation is COR% = 30.8. Repeatability of oxygen consumption during aerobic phase, isocapnic buffer phase and hypocapnic hyperventilation phase is COR% = 19.0, COR% = 18.4 and COR% = 40.7 respectively. The best predictors of high VO2max was ventilatory anaerobic threshold (test1: r=0.89, test2: r=0.90), isocapnic buffer phase (test1: r=0.89, test2: r=0.86) and onset of blood lactate acid accumulation (test1: r=0.85, test2: r=0.97), all are significantly correlated. We obtained 90 of 140 (64%) systolic and 99 of 140 (71%) diastolic blood pressure measurements. Mean values for all systolic blood pressure measurements were 150±22 mmHg during test 1 and 153±24 mmHg during test 2, diastolic values were 84±14 mmHg and 83±11 mmHg. Systolic blood pressure increases with exercise time and reaches a peak of 174±13 mmHg at a heart rate of 160 bpm (92% of heart rate at VO2max). Diastolic blood pressure seems to remain constant throughout the exercise test. Systolic blood pressure measurements are more repeatable (COR% = 28.1) than diastolic measurements (COR% = 37.8). It seems like lack of blood pressure repeatability is the same over the whole blood pressure range.

**Discussion/Conclusion**

Our study confirms that VO2max obtained by an incrementing treadmill test, is highly isocapnic (COR% = 8.5) and a hypocapnic hyperventilation phase. When examining oxygen consumption in each phase, we find differences due to exercise status or decease. Athletes have a wide isocapnic buffer phase and VO2max due to increased CO2 buffer capacity in the muscle. The importance for physical fitness of well-developed CO2 buffers in muscles, are emphasised through the good correlation between isocapnic buffer phase and VO2max (test1: r=0.89, test2: r=0.86). Unpublished data in our laboratory reports a good correlation between aerobic phase and VO2max for patients with mild hypertension operated for coarctation of the aorta, due to disturbed blood pressure regulation and high blood perfusion in muscles. The healthy participants in the present study have no such correlation between aerobic phase and VO2max. Oxygen consumption during aerobic phase, VO2max and confirm that anaerobic thresholds achieved at high oxygen consumption predict high VO2max. We can divide the oxygen consumption during an incrementing exercise test into an aerobic phase, an anaerobic threshold than lactic acid threshold, isocapnic buffer phase (COR% = 18.4) are more repeatable than obtained by cycle (COR% = 11.0). Sub-maximal values indicate that ventilatory anaerobic threshold is achieved just before lactic acid threshold. They probably represent the same incident in the middle of the isocapnic buffer phase. This is a logical result since isocapnic buffering represents a gradual transition from aerobic to anaerobic exercise. However, ventilatory anaerobic threshold (COR% = 11.0) is more repeatable as indicator of anaerobic thresholds obtained as end tidal CO2 pressure begin to decrease and ventilatory CO2 equivalent (ventilation/CO2 production) begin to increase and indicated the second ventilatory breakpoint. Aerobie phase is defined as the oxygen consumption between zero and onset of isocapnic buffering. Isocapnic buffer phase is the oxygen consumption between onset of isocapnic buffering and onset of hypocapnic hyperventilation. Hypocapnic hyperventilation phase is the oxygen consumption between onset of hypocapnic hyperventilation and VO2max.
of sphygmomanometric blood pressures without comparison to direct intra-arterial measurement. We obtained 90 of 140 (64%) systolic and 99 of 140 (71%) diastolic blood pressure measurements. This illustrates the difficulties in the method and in many cases one exercise test is not sufficient to obtain a clear picture of blood pressure response. Mean values indicate that systolic blood pressure increases with exercise time, reaches a peak at 12 minutes at a heart rate of 160 bpm (82% of heart rate at VO2max). Diastolic blood pressure seems to remain constant throughout the exercise test. Systolic blood pressure (COR% = 28.1) was more repeatable than diastolic (COR% = 37.8). Repeatability for these measurements are less than for ambulatory blood pressure measurements (systolic COR% = 21.5 and diastolic COR% = 22.4, Roy Olsen et al. 2002). This is not surprising since persons undergoing ambulatory measurements are told to stop activity while blood pressure is measured. Noise interference during exercise often makes it hard to trust an obtained reading and this influences repeatability. It is however not certain that the difference in repeatability between ambulatory and exercise measurements is only due to movement artefacts since the lack of repeatability during exercise seems to be the same over the whole blood pressure range. Natural variation in a person’s blood pressure is higher while exercising, and this can therefore contribute to a difference in blood pressure responses between two tests. Despite the mentioned difficulties in measuring blood pressure during exercise, we are convinced that the method can reveal significant changes in blood pressure response. When dealing with patients it is mandatory to discover both exercise induced hypertension and blood pressure fall. It is often advisable to exercise patients on a treadmill since they then recruit large muscle mass making them able to achieve higher oxygen consumption without stopping due to lactic acid accumulation in smaller muscle groups. In our experience it is easier to motivate small children for treadmill than for cycle exercise.

References

EXERCISE TESTING AFTER REPAIR OF COARCTATION OF THE AORTA

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Keywords: blood pressure, oxygen consumption, anaerobic threshold

Introduction
Coarctation of the aorta is an obstruction of the aorta, usually where the arch continues into the descending aorta at the site of the arterial duct. It represents 5 to 7 % of the congenital cardiovascular malformations. The degree of stenosis may vary from a mild coarctation without significant haemodynamic effects to an interrupted aortic arch with devastating effects on the circulation when the arterial duct closes. The origin of the left subclavian artery is affected in some patients. There has been reported a mortality rate of 0 to 20 % in coarctation patients (Thu et al. 1999), which depends on several factors such as: severity of obstruction, heart failure before surgery, age at surgery, surgical technique applied and the complexity of associated heart malformations. The most common complications after surgery are abnormal blood pressure response during physical exercise, restenosis, hypertension, and aortic valve stenosis mostly in patients with a bicuspid aortic valve and aneurysms of the aorta. Even without recoarctation after surgery, these patients often have hypertension at rest or an abnormal blood pressure response during exercise, leading to premature death. Some patients need reoperation or balloon dilatation because of a rest- or recoarctation. There is dispute regarding what resting systolic blood pressure difference between right arm and leg, require intervention. In this study we have investigated how the resting systolic blood pressure difference between right arm and leg immediately after exercise, and transition from aerobic to anaerobic exercise. Our hypothesis is that exercise testing is necessary to reveal exercise induced hypertension, that there is no relation between systolic blood pressure at rest and during exercise, and that increased blood pressure has an effect on the transition from aerobic to anaerobic metabolism.

Methods
The inclusion criteria for the 41 subjects studied during a 19 months period, were patients aged 15–40 years with coarctation of the aorta repaired at Haukeland University Hospital, Bergen, Norway in the period 1975-98. We divided the patients in three groups depending on their resting supine systolic blood pressure difference between right arm and thigh. Group 1 had a systolic blood pressure difference between right arm and leg immediately after exercise, and transition from aerobic to anaerobic exercise. Our hypothesis is that exercise testing is necessary to reveal exercise induced hypertension, that there is no relation between systolic blood pressure at rest and during exercise, and that increased blood pressure has an effect on the transition from aerobic to anaerobic metabolism.
pressure recordings in the arm. This instrument has an automated pressure cuff and a pressure sensor. Dinamap XL Vital Signs Monitor (Critikon Inc., Arlington, TX, US) was used for recordings in the leg. This instrument has automated pressure cuffs and is an oscillometric blood pressure monitor. Heart rate was measured with a Polar and onset of hypocapnic hyperventilation (Finn-90440, Kempele, Finland), and ECG was registered using Sensormedics 4-lead system. Arterial oxygen saturation was measured using Sensormedics’ pulsioxymeter on the index finger of the patients’ left hand. Maximal oxygen consumption was defined as the highest oxygen consumption measured during exercise. We assumed that maximal oxygen consumption was achieved when two of four criteria were met. The criteria are subjectively felt exhaustion, the presence of an oxygen consumption plateau despite increasing exercise intensity, attainment of 95% of the age-predicted maximal heart rate and a respiratory exchange ratio equal to or greater than 1.05, during the final increment of the exercise test. 12 of 41 patients were defined by the exhaustion criterion. The onset of isocapnic buffering (Wasserman et al. 1994) was defined as the oxygen consumption when both the end tidal oxygen pressure and the ventilatory oxygen equivalent (ventilation/oxygen consumption) began to increase. The onset of hypocapnic hyperventilation (Wasserman et al. 1994) was defined as the oxygen consumption between onset of isocapnic buffering and onset of hypocapnic hyperventilation. Hypocapnic hyperventilation phase was defined as oxygen consumption between threshold for onset of hypocapnic hyperventilation and maximal oxygen consumption. All data are expressed as means ± SD unless otherwise indicated. The Pearson correlation coefficient and linear regression analysis describe the relationship between different parameters when appropriate. A standard two-sided t-test for comparison of two groups of data with different standard deviations is used to describe significance. A p-value < 0.05 is considered statistically significant.

Results
We find significantly higher resting systolic blood pressure for group 2 compared to group 1 (p<0.0001), and significantly higher resting systolic blood pressure for group 3 compared to group 2 (p<0.01). Group 3 compared to group 1, has significantly higher systolic blood pressure difference between right arm and leg immediately after exercise (p<0.02). Maximal systolic blood pressure during exercise is not significantly different between the groups, although higher in group 3. There is a good correlation between resting systolic blood pressure difference between right arm and leg and resting systolic blood pressure (r =0.81, p<0.01). In all groups there was a good correlation between ventilatory anaerobic threshold and maximal oxygen consumption (group 1: r=0.76, p<0.01; group 2: r=0.88, p<0.01; group 3: r=0.78, p<0.01). Oxygen consumption (in percent of maximal oxygen consumption) at this threshold was not significantly different between the groups: 49±14, 47±8 and 49±9 for groups 1, 2 and 3, respectively. The aerobic phase is significantly wider in group 2 compared to group 1 (p<0.03). There is a tendency to narrower isocapnic buffering zone (p<0.2) and increased maximal oxygen consumption (p<0.2) in group 2 compared to group 1, and a wider hypocapnic hyperventilation zone in group 3 compared to group 1 (p<0.1). The maximal oxygen consumption is reduced in group 3 compared to group 2, although not significantly. Males are however over-represented in group 3 compared to group 1 and 2, which probably disturbs a significant reduction in maximal oxygen consumption. Group 1 has significant relation between maximal oxygen consumption and isocapnic buffering phase. Groups 2 and 3 have significant relations between maximal oxygen consumption and aerobic phase. All groups have significant relations between maximal oxygen consumption and hypocapnic hyperventilation phase.

Discussion/conclusion
Our study has confirmed that hypertension at rest or in response to exercise remains a considerable problem in patients after surgical repair of coarctation of the aorta. We find that there is a good correlation between resting systolic blood pressure difference between right arm and leg and the resting systolic blood pressure (r =0.81, p<0.01). Patients in group 1 have normal systolic blood pressure, group 2 has mild hypertension and group 3 has hypertension. We find that neither the resting systolic blood pressure, nor the resting systolic blood pressure difference between right arm and leg, are good indicators for either maximal systolic blood pressure or systolic blood pressure difference between right arm and leg immediately after exercise. Thus, it is important to measure blood pressure during exercise to reveal exercise induced hypertension or increased blood pressure difference between right arm and leg. Blood pressure in the arm cannot easily be measured during exercise due to movement artefacts. 33 of 41 patients in this study could be measured during exercise. It has been questioned if the blood pressure difference between right arm and leg immediately after exercise is accurate enough to serve as an indicator for exercise induced blood pressure difference at maximal exercise (Engval et al. 1995). The measurements are most difficult to obtain in the leg. We tried to obtain these in the leg as soon as possible after exercise, and succeeded in supine recordings within 2 minutes after maximal exercise in 35 of the 41 patients. Because of high resting systolic blood pressure for group 3, we are convinced that a resting systolic blood pressure difference between right arm and leg above 20 mmHg (group 3) should serve as an indication for catheterisation in light of hypertension during exercise and echo-Doppler or MRI detected residual coarctation. We recommend regular follow up of group 1 patients, because patients often develop hypertension or abnormal blood pressure response to exercise with prolonged follow up time (Clarkson et al. 1983). In the present study we wanted to illustrate the impact of blood pressure on transition from aerobic to anaerobic exercise. It has recently been described an excessive dependence on anaerobic metabolism during exercise in patients with repair of the aorta and hypertension (Rhodes et al. 1997). Their conclusion is partly confirmed in our material where we have found significant relations between maximal oxygen consumption and hypocapnic hyperventilation phase in all three groups. Ventilatory
an aerobic threshold is correlated to maximal oxygen consumption in all three groups, and seems to be a good parameter for evaluating the anaerobic threshold in these patients. The ventilatory anaerobic threshold can however not differentiate the degree of illness. An interesting finding is that group 2 patients have a significantly lower aerobic phase and higher maximal oxygen consumption compared to group 1 and the wide aerobic phase predicts the higher maximal oxygen consumption. This is a striking difference compared to group 1 where wide isocapnic buffering phase predicts higher maximal oxygen consumption, which is normal for healthy persons. A slight increased blood pressure in group 2 seems to help in achieving higher maximal oxygen consumption. The reason for this could be a disturbance of the blood pressure regulation due to anatomical and physiological changes. Blood pressure overcompensates the peripheral resistance securing a better peripheral blood flow. Overcompensation of a slight increase in aortic resistance can contribute to a slight cardiac hypertrophy, increasing stroke volume and muscle-perfusion, as seen in athletes. A higher blood flow in the muscle facilitates longer duration of aerobic work and this increases the exercise capacity. Isocapnic buffering phase is however decreased, opposed to athletes, and thereby limiting a great increase in exercise capacity. When the resting systolic blood pressure difference between right arm and leg becomes too high, as it does for group 3 patients, there will be a large load on the heart and hypertensive effects on the heart and peripheral circulation will develop. This leads to a narrower aerobic phase. Maximal oxygen consumption is reduced and isocapnic buffering zone does not predict maximal oxygen consumption. It is reasonable to think that an even higher resting systolic blood pressure difference between right arm and leg will induce an even higher restrain on the maximal oxygen consumption.

References
Jan;60(6):2020-7

ARRHYTHMIA AND PHYSICAL ACTIVITY IN CHILDREN

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Introduction
Hyperkinetic supraventricular and ventricular arrhythmias are very frequent in the pediatric age and could be accompanied and/or imply for acute or chronic heart diseases. To establish the safety for the practice of physical activity it is necessary to exclude the presence of heart diseases and then to evaluate, non-invasively, the simple and/or the complex types.

Aim of the study: to evaluate the behaviour of the arrhythmias (supraventricular and ventricular) towards the practice of physical activity in young athletes.

Material and Methods
45 pts have been examined in our laboratory to perform Montoye Step Test to obtain the clearance for competitive sports; 37 of them (26M; 11F) with a mean age of 10.5±3 years were selected for not-repetitive arrhythmias. All the 37 patients were asymptomatic with a negative familial and personal history of the cardiovascular apparatus. All patients underwent to: 1) cardiovascular examination; 2) 2D-color doppler echocardiography; 3) exercise testing on the treadmill; 4) 24 hours Holter monitoring.

The treadmill test was performed with Bruce protocol and stopped for symptoms or muscular fatigue. We have analysed time of exercise test in minutes, heart rate at rest and at peak of exercise, blood pressure, measured with the Riva-Rocci method with aneroid sphygomanometer, at rest and at peak of exercise and behaviour of arrhythmia during the test and in the recovery. In the 24-hours Holter monitoring we have valued the total number of heart beats and the number of ectopic beats and so we have calculated the percentile to do a comparison during the follow-up.

Yearly follow-up was done for 4.1 ± 2 years.

Results
The cardiovascular examination and the echocardiogram were negative; exercise testing on the treadmill showed a good exercise tolerance (>75% of the theoretical values) and a disappearance of the arrhythmia with the increase of the heart rate in all patients. They were then divided in two classes in relation to the arrhythmia recorded at the 24 hours Holter monitoring: 1) 17 pts (13M; 4F) supraventricular premature complex; 2) 20 pts (13M; 7F) ventricular premature complex. We observed: a) the disappearance of the arrhythmia in 47% of the group 1 and in 40% of the group 2; b) a quantitative increase of the arrhythmia in 12% of the group 1 and in 25% of the group 2 (still not-repetitive); c) a reduction of the arrhythmia in 41% of the group 1 and in 35% of the group 2.

| Table 1. Follow-up of patients with arrhythmia.
| A | 17 | 8 | 2 | 7 |
| B | 20 | 8 | 5 | 7 |

Legend: A = patients with supraventricular premature complex; B = patients with ventricular premature complex

Conclusions
In the presence of simple arrhythmia phenomena in normal heart is possible to practice safely physical activity and competitive sports, performing yearly medical examinations of second level (exercise testing and 24 hours Holter monitoring).
Oscillatory Changes of Oxygen Uptake During Exercise in Cardiomyopathy: Relationship with Clinical Status

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Keywords: gas exchange, oxygen uptake kinetics, congenital heart disease

Introduction
Oscillatory changes of the parameters of gas exchange during exercise, have been reported in patients with congestive heart failure and have been ascribed to hemodynamic dysfunction. The aim of the present study was to analyse if this phenomenon is also observed in patients with cardiomyopathy (CMP).

Patients and Methods
14 children with CMP (7 with dilated DCMP, and 7 with hypertrophic HCMP) were selected for this study and underwent exercise testing on a treadmill. At one minute intervals the inclination of the treadmill was increased by 2% while the speed remained constant (5.6 km/h). These patients were compared to 29 normal controls (C) of the same age range, and 8 patients with a ventricular septal defect (VSD). Age at testing averaged 9.6 ± 3.6 years for DCMP, 11.4 ± 3.3 years for HCMP, 12.1 ± 2.4 years for VSD and 10.4 ± 2.9 years for normal controls (P >0.25). Gas exchange was measured breath-by-breath by mass spectrometry. Variability of VO2 was determined as the difference between all single breaths during one minute of those breaths, expressed as a percentage of the mean value for VO2 during that minute.

Results
Significantly (P<0.05) elevated values were found for oscillatory changes in VO2, expressed as percent variability, in patients with DCMP (varying from 7.3 to 11.7 %, for different levels of inclination on the treadmill), when compared to HCMP (5.1 - 6.7 %), VSD (5.6 - 7.7 %) and C (5.8 - 7.4 %). No significant difference was found between HCMP VSD and C. Patients with the highest value for variability of VO2 (exceeding the 95 % CI of normal) were characterised by the lowest value for shortening fraction, determined on the echocardiogram (15-17%).

Conclusion
Increased oscillatory changes of VO2 during exercise in DCMP correlate with hemodynamic dysfunction of the left ventricle and suggests inadequate oxygen delivery to the exercising tissues.

Metabolic Cost and Preferred Step Length in Children with Spastic Cerebral Palsy

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Keywords: oxygen uptake, step length, cerebral palsy

Introduction
The aerobic demand (VO2) required to walk or run at a given submaximal speed is an important determinant of overall physical stress during locomotion. Results from a number of studies have shown that young and old adults typically adopt step length patterns that minimize VO2. Moreover, recent data suggest that energy use is optimized when able-bodied children walk at preferred step lengths (PSL). The extent to which metabolic cost is a self-optimizing feature of walking is still unclear. Against this backdrop, the purpose of our study was to determine whether children with spastic cerebral palsy (CP) select step length patterns that minimize the energy demands of walking.

Methods
Three children with spastic hemiplegia and one child with spastic diplegia (3 males, 1 female; age range = 5 to 12 years; mean height = 138.1 ± 21.5 cm; mean body mass = 40.0 ± 24.3 kg) volunteered to participate in this study. Following initial exposure to treadmill walking (Session 1) and two additional testing bouts involving the acquisition of step length and VO2 data at a variety of walking speeds (Sessions 2 and 3), each subject walked for five minutes at five randomly-assigned step length conditions (PSL and -10%, -5%, +5% and +10% of leg length (LL) from the PSL) at either 0.67 m s-1 (n = 2) or 0.89 m s-1 (n = 2) (Session 4). Step length patterns were manipulated by having subjects match their stepping frequency to the beat of an amplified audible signal generated by a computer-receiver interface. To reinforce the audible feedback, a computer screen provided a constantly-updated visual confirmation of the accuracy of subjects’ attempts to attain desired step length values. During the last two minutes of each step length condition, VO2 was quantified by analyzing a 2-min expired gas sample collected in a meteorological balloon. Step length values were obtained from a computer-footswitch interface operating at a sampling frequency of 200 Hz. For each subject, a curve-fit routine was used to generate polynomial equations best expressing the association between step length and VO2.

Results
Analysis of mean data revealed that VO2 was lowest at the PSL condition and rose in a curvilinear fashion as step length was varied away from the PSL. At the shortest and longest step length conditions, VO2 increased by an average of 4.7 and 2.8 ml kg-1 min-1, respectively, compared to the VO2 measured at the PSL. Examination of individual SL-VO2 curves demonstrated that the mean absolute difference in relative step length between the PSL and the energetically-optimal step length was 1.64% of LL. This deviation in relative SL corresponded to an average VO2 difference of 0.1 ml kg-1 min-1.
Conclusion

Taken together, these preliminary data suggest that optimization of metabolic cost may be an important factor underlying the choice of step length patterns during walking in children with spastic cerebral palsy.

Acknowledgement

Supported by the National Institute of Child Health and Human Development (HD 30749)

References


BONE MINERAL DENSITY, PHYSICAL ACTIVITY, CALCIUM INTAKE AND SEVERITY OF DISEASE IN CHILDREN WITH JUVENILE IDIOPATHIC ARTHRITIS

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Keywords: juvenile idiopathic arthritis, bone mineral density, physical activity

Juvenile Idiopathic Arthritis (JIA) is associated with low bone mineral density and increased risk of osteoporosis later in life. Physical activity during childhood is generally thought to have a positive influence on skeletal development. The purpose of this study was to determine areal bone mineral density (aBMD) and ultrasound properties in children with JIA, and the relationships to physical activity, aerobic fitness, muscle strength, calcium intake, severity of disease, and corticosteroids.

This was a matched case-control study including two groups of 24 children aged 5 to 16 years (mean 10.13 +/- 2.70 SD): JIA children and controls. Groups were matched for gender, age, height, weight and pubertal stage. Primary measures included total body (TB), lumbar spine (L2-4), left and right femoral neck (FN) and greater trochanter (GT) aBMD by dual energy x-ray absorptiometry (DXA-Lunar Prodigy), and calcaneal speed of sound (SOS) by quantitative ultrasound (Lunar Achilles +). Other measures included physical activity level by Modifiable Activity Questionnaire For Adolescents; VO2peak by direct gas analysis during treadmill test; isokinetic knee flexion and extension peak torque by dynamometer; body composition by DXA; calcium intake by Food Frequency Questionnaire; joint count; inflammation by erythrocyte sedimentation rate (ESR) and serum C-reactive protein level; pain and disease activity by Childhood Health Assessment Questionnaire.

There were no significant differences among groups for age, height, weight, pubertal stage, body composition, physical activity, VO2peak, muscle strength or calcium intake. Left FN and GT aBMD, and left SOS were significantly lower in JIA, compared to controls. There was a trend toward reduced right FN (P=0.13) and GT (P=0.10) aBMD, and SOS (P=0.11) in the JIA compared to the control group. In JIA subjects, aBMD at all sites correlated positively (P<0.05) with physical activity level, VO2peak, muscle strength and lean tissue mass (LTM), and correlated negatively with joint count, ESR, pain and disease activity. Left SOS correlated negatively with joint count, ESR, pain and disease activity. Left SOS correlated positively with VO2peak and LTM. Fourteen (58%) and 5 (20%) children had arthritis at the left and right leg, respectively. Only one of them was treated by corticosteroids. Mechanical loading applied on lower limbs may be decreased in children with JIA, in relation with pain and altered joint function, resulting in sub-optimal skeletal development at weight-bearing sites.

EFFECT OF DYNAMIC FOOT ORTHOTICS ON THE MOTOR SKILLS OF CHILDREN WITH DEVELOPMENTAL DELAYS

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Keywords: orthotics, developmental delays, motor skills

Introduction

Dynamic foot orthotic (DFO) is a general term that describes a thinly layered shoe insert, which is placed in the shoes of children with motor delays in order to improve their balance and motor capacities. DFOS can be used as a therapy device that allows a child with developmental delays (e.g., children generally classified with developmental delays due to low muscle tone, as in Down syndrome) to quickly (i.e., within days) improve their postural control and balance. DFOS are designed to give mild mechanical support and proprioceptive feedback to children who have relatively normal strength and control of their thigh and calf muscles, but poor control of their feet. The type of DFO used in this study is specific for children with “low tone” motor delays (i.e., as opposed to “high tone” motor problems like spasticity seen in children with cerebral palsy) and is clinically identified as a minimum control orthotic (MCO). MCOs are shoe inserts that contain one layer of foam and a thin layer of polyethylene plastic which provides greater structural support and is more resilient than a typical foam shoe insert.

There have been descriptive and observational reports (i.e., anecdotal) on the benefits (e.g. improved balance and motor skills) of MCOs in treating neurological and developmental disorders (Hylton, 1989), but there is a paucity of scientific data regarding the effectiveness of MCOs. Therefore, the purpose of this study is to add to the body of knowledge on MCOs and their efficacy as it relates to motor skills of children with various “low tone” developmental delays. Specifically, this study examined the effects that a 2-month therapeutic program using MCOs has on the locomotive scores of the Peabody Developmental Motor Scales-II in children with developmental motor delays.

Methods

Participants

Sixteen children (9 male, 7 female; age = 44.0 +/10.7 months) with developmental delays (2 Down syndrome, 1 Dandy-Walker cyst, 1 cerebral palsy and 12 motor delayed) participat-
ed in this study. Classification of developmental delayed (DD) was determined by a medical diagnosis from a physician using appropriate diagnostic instruments and procedures. Parental/guardian informed consents were obtained prior to testing and approval for the study was obtained from the University Institutional Review Board.

Instrument

The locomotion section of the Peabody Developmental Motor Scales Test, 2nd edition (PDMS-2) was selected to evaluate the participants motor abilities. The PDMS-2 was designed to assess the gross and fine motor skills in children from birth to six years of age. These motor abilities include, but are not limited to: standing, walking up and down stairs, walking fast, walking backward, walking sideways, walking a line, jumping up, jumping forward, jumping down, and running. The PDMS-2 norms are based on scoring each item as 2 (the child performs the item according to the criteria specified for mastery), 1 (the child's performance shows a clear resemblance to the item mastery criteria but does not fully meet the criteria), and 0 (the child cannot or will not attempt the item, or the attempt does not show that the skill is emerging). The PDMS-2 has been shown to be a reliable and valid method of determining motor skills in children 0 to six years of age (Aiken, 1994; Nunnally & Bernstein, 1994; and Salvia & Ysseldyke, 1998).

Procedure

Two registered physical therapists (RPT) administered the PDMS-2 to each participant. Each RPT scored the test separately, scores were then compared and discussed by the RPTs, and the agreed score was used for data analysis. An initial test was given without wearing the minimum control orthotic (MCO). The child’s shoe was then fit with the MCO and the agreed score was used for data analysis. An initial test with the MCO was given without wearing the MCO following two months of wearing the MCO, with at least 24 hours between tests.

Table 1. PDMS-2 Initial and 2 Month Test Scores

<table>
<thead>
<tr>
<th></th>
<th>Raw Without MCO</th>
<th>Motor Age Equivalent Without MCO</th>
<th>With MCO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial (n=16)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>110.3±21.5</td>
<td>114.7±23.3 *</td>
<td>25.7±7.6</td>
<td>27.2±8.4 *</td>
</tr>
<tr>
<td>2 months (n=15)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>115.4±25.3</td>
<td>120.2±27.6 *</td>
<td>28.4±9.7</td>
<td>30.7±11.2 *</td>
</tr>
</tbody>
</table>

*p = p<0.05

Discussion

Previous anecdotal reports have suggested that DFO improve balance and motor skills in children with neurological and developmental disorders (Hylton, 1989). However, there has yet to be reported research data regarding the effectiveness of DFO. In this study, a specific type of DFO, a minimum control orthotic (MCO), was evaluated to determine their capacity in improving the motor skills of children with various “low tone” developmental delays. The results of this study suggest that MCO do improve the motor capacities of these children.

References


Clinical/Medical Aspects in Pediatric Exercise Science

IN ADOLESCENTS AGED 14-16 YEARS

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Keywords: low-back pain, exercise, intervention

The aim of this investigation was to evaluate the efficacy of a specific exercise programme as an intervention to treat recurrent non-specific low-back pain in adolescents. A randomised controlled trial was conducted with an experimental group (boys n=16, girls n=11, age 14.6(0.6) years) who participated in a specific 8-week exercise programme and a matched control group (boys n=16, girls n=11, age 14.6(0.5) years) who continued with normal daily activities. All subjects were identified as having recurrent non-specific low-back pain via questionnaire and then interview. Pre and post intervention measures of low-back pain status (pain severity and consequences reported in 1-week diaries), and health-related fitness were taken. Two-way mixed ANOVA (independent variables: pre/post and experimental/control) was conducted for each variable, significant was set at P=0.05. In terms of the consequences and symptoms of low-back pain significant interaction effects were identified for the number of pain occurrences (F1,52=4.65, P=0.04), the perceived severity of the pain (F1,52=71.74, P=0.00) and number of occasions missing sport or physical activity due to the low-back pain (F1,52=16.85, P=0.00). In each case significant improvement was noted in the experimental group, effect sizes ranged from 0.27 to 1.47. In terms of health related fitness, significant interaction effects were identified for sit and reach performance (F1,52=103.25, P=0.00), hip range of motion with the knee flexed (F1,52=69.51, P=0.00) and extended (F1,52=52.04, P=0.00), lumbar sagittal mobility (modified Schöber, F1,52=69.51, P=0.00), lateral flexion of the spine (F1,52=29.03, P=0.00) and number of sit-ups in 60 s (F1,52=45.25, P=0.00). In each case significant improvement was noted in the experimental...
group, effect sizes ranged from 0.52 to 0.91. No significant interaction effects were identified for absence from school due to low-back pain, body mass index, sum of four skinfolds or grip strength. No significant relationship was identified between the concurrent reduction in pain and improvement in health-related quality of life and the change in the weight of the backpacks. This change occurred through an alteration of pain perception and coping strategies. It was concluded that a specific exercise programme acted as an effective short-term treatment strategy for recurrent non-specific low-back pain in adolescents. Further evaluation is required to assess the long-term effectiveness.

**References**


**PREDICTION OF PERCENT BODY FAT IN CHILDREN USING SKINFOLDS FROM THE UPPER AND LOWER BODY**

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**Keywords:** body fat, skinfolds, thigh

Studies to assess total body fat from surface anthropometric techniques in children have generally used upper limb or trunk skinfolds as prediction variables. However, skinfolds from the lower limb, especially the anterior thigh region, are better predictors of body fat in adults. The purpose of this study was to assess whether the addition of a skinfold from the lower body would improve the prediction of percent body fat when this was predicted from the sum of the triceps and subscapular skinfold, as this combination of skinfolds is commonly used to predict body fat in children (Slaughter et al., 1988; Human Biology, 60: 709-723).

Twenty eight children, 17 girls (age 9.3 ± 0.5 y; ht 134.0 ± 6.0 cm; mass 33.5 ± 8.7 kg) and 11 boys (age 9.8 ± 0.5 y; ht 136.3 ± 9.2 cm; mass 33.2 ± 6.5 kg) volunteered to participate. Percent body fat (%fatUW) was estimated by hydrodensitometry, using equations for prepubertal children. Skinfold measurements were taken at the triceps, subscapular, anterior thigh and medial calf. All skinfolds were made available in a stepwise multiple regression analysis. This also included the sum of the triceps and subscapular skinfolds (triceps+subscap) and the sum of the calf and thigh skinfolds. Further analyses involved hierarchical multiple regression analyses to account for the unique variance in %fatUW from the thigh and calf skinfolds, when these were added to the sum of triceps and subscapular skinfolds.

Stepwise regression analysis with all variables made available for inclusion in the analysis produced the following equations: %fatUW in girls = 8.8 + 0.65 (thigh skinfold), R² = 0.41; %fatUW in boys = 3.5 + 0.9 (triceps+subscap) , R² = 0.47. For girls, the addition of the triceps+subscap to the thigh accounted for less than 0.5% variance in %fatUW. For boys, the addition of the thigh to the triceps+subscap accounted for no further variance in %fatUW. When the thigh skinfold was forced into the analysis at the first step (R² = 0.45), the additional variance accounted for by inclusion of the triceps+subscap (2.0%) was non-significant (P=0.57).

In conclusion, this study provides evidence for the potential usefulness of the thigh skinfold for predicting percent body fat in children, especially girls.

**BIOMECHANICAL ANALYSIS OF ACUTE BACKPACK LOAD CONSEQUENCES ON CHILDREN’S GAIT**

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**Keywords:** biomechanics, gait analysis, loads

**Introduction**

It is usual to see in school very fragile children carrying voluminous and very weighted backpacks with consequent overload in their locomotor structures. Studies in the literature showed that for children in school age, the limits of load carried should not be superior than 10 to 15% of body weight (Voll and Klimt, 1977, Pascoe et al., 1997, Hong et al., 2000).

Many studies showed that increasing load, specially when the load is above 30% of the weight of the children, may lead to chronic back-pain with harmful consequences in their growth and motor development, in their health and in the student’s well being.

This study was performed to understand the usual way how children transport their bags, as well as the fluctuation of the backpack’s weight during a school week and the association of these loads with back-pain symptoms, and (iii) the biomechanical repercussions in gait and balance of children transporting these loads.

**Methods**

An epidemiological study was performed to understand the fluctuation of the backpack’s weight during a school week and the usual way how children transport their bags, as well as the incidence of back-pain. The experimental study included: (i) a 3D kinematical analysis (ARIEL APAS system), (ii) a dynamometric analysis (Bertec Force plate), (iii) a podobarmetric analysis (PEDAR plantar pressure system). These approaches were used for gait analysis of children with three different loads situations (0%, 15% and 30% of the body weight).

**Results**

The results showed that most of the children carry overloaded backpacks. 89% of the inquired children carried a backpack that weighted 15% of their own body weight and 83% of these children had already reported back-pain, probably related with their overloaded backpacks. These backpacks are responsible for an increase of the trunk angle that may lead eventually to muscle skeletal injuries. The results also showed that there are acute biomechanics repercussions in gait and balance with the increasing load, specially when the load is above 30% of the individuals body weight. These situations, repeated in a daily basis, may lead to chronic back-pain with harmful consequences in their growth and motor development, in their health and in the student’s well being.

**References**

PORTUGUESE OBESITY IN MALE AND FEMALE SCHOOL AGE CHILDREN: EPIDEMIOLOGICAL STUDY AND OBESITY CUT OFF POINTS VALIDATION

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Keywords: body mass index, obesity, overweight

Nowadays the incidence of obesity in childhood is considered a public health problem in developed countries. The main related factors are sedentary lifestyles, physical activity and diet. Therefore, one of the main concerns of public health policies must be related to the estimation of the incidence of overweight and obesity, mainly in children in order to prevent the associated risks in adults (active population). Therefore, the main purpose of the present study is, on one hand, estimate the incidence rate of obesity in school age Portuguese children and, on the other hand, validate the proposed cut off points from Cole et al. (2000) for the Portuguese Population. The sample was constituted by 2651 children (1330 females and 1321 males) ranged between 6 and 10 years old, which attending primary school. For obesity and overweight criterion we used the Body Mass Index distribution (above 25 Kg/m² and above 30 Kg/m²) according to the cut off points defined and used by Cole et al. (2000). To compare the BMI index between genders we used the analysis of variance. To adjust the BMI index to the distraction caused by the age we use the analysis of covariance. The results confirm that girls have grater relative fatness percent than boys from 5/6 years through adolescence (Malina, 2000). The results can be explained either by growing and maturation factors but also by socio cultural factors. Girls are brought up and educated to stay at home to play in small spaces; boys on the contrary are encouraged to go out to have more dynamic games. The differences between genders in what concerns the way in which they are brought influence the way in which they expend the energy in the spar time. Trends toward greater BMI and obesity is impor tant in the context of public health because: BMI tends to track well after early childhood, obese children are at increased risk for diabetes and other health and orthopedic problems, and childhood obesity predicts adult obesity (Crespo and Smit, 2003) and %Fat means also indicate a high prevalence of obesity (boys=28.0±5.3%, girls=31.5±5.6%), and T children are fatter than NT children (Table 1).

Table 1. Percentages of children identified as obese and super-obese by 85th and 95th percentiles for BMI and TRI (NHANES I, Must et al., 1991) and % Fat estimates by sex and tribal membership status (Lohman et al., 1999).

<table>
<thead>
<tr>
<th></th>
<th>Boys All</th>
<th>T</th>
<th>NT</th>
<th>Girls All</th>
<th>T</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>104</td>
<td>60</td>
<td>44</td>
<td>86</td>
<td>45</td>
</tr>
<tr>
<td>Obese n</td>
<td>23.1%</td>
<td>23.3%</td>
<td>10.2%</td>
<td>23.3%</td>
<td>24.2%</td>
</tr>
<tr>
<td>Obese %</td>
<td>32.7%</td>
<td>35.0%</td>
<td>29.5%</td>
<td>27.9%</td>
<td>23.2%</td>
</tr>
<tr>
<td>Super-obese n</td>
<td>53</td>
<td>29</td>
<td>24</td>
<td>40</td>
<td>23</td>
</tr>
<tr>
<td>Super-obese %</td>
<td>11.1%</td>
<td>6.9%</td>
<td>4.3%</td>
<td>15.0%</td>
<td>3.2%</td>
</tr>
<tr>
<td>BMI</td>
<td>60.4%</td>
<td>24.1%</td>
<td>16.7%</td>
<td>35.0%</td>
<td>10.0%</td>
</tr>
<tr>
<td>TRI</td>
<td>68</td>
<td>68</td>
<td>68</td>
<td>98</td>
<td>49</td>
</tr>
<tr>
<td>%Fat (mean±SD)</td>
<td>28±0.5±5</td>
<td>28±2.5±5</td>
<td>27±8.5±5</td>
<td>31±5.5±6</td>
<td>32±4.5±6</td>
</tr>
</tbody>
</table>

Discussion and Conclusions
Assessments of BMI, TRI, and %Fat indicate an obesity prevalence of 21-33% in AI and non-AI children ages 5-10, and confirm earlier findings of widespread prevalence of obesity in AI children (Jackson, 1993; Lohman et al., 1999; Story et al., 1999). Obesity prevalence varies with the criterion used; however, the prevalence is higher in T than in NT children. Trends toward greater BMI and obesity in children are important in the context of public health because: BMI tends to track well after early childhood, obese children are at increased risk for diabetes and other health and orthopedic problems, and childhood obesity predicts adult obesity (Crespo and Smit, 2003; Dwyer et al., 1999; Guo and Chumlea, 1999; Serdula et al., 1993). Funding and implementation of community-based physical activity and nutrition education programs are needed to prevent and reduce obesity and its sequelae (Story et al., 1999).
Methods
The patients underwent square wave exercise testing on a treadmill. The speed was set at 5 km/h and the inclination at 4%. The oxygen deficit was calculated by subtracting the VO2 measured at the onset of exercise from the steady-state VO2 obtained at the end of the exercise. These differences were cumulated and expressed as a percentage of the cumulated oxygen cost for the 6 min exercise test. All data are expressed as mean and standard deviation of the mean.

Results
In the obese patients, the oxygen deficit amounted to 7.2 ± 1.9% and was not significantly different from the value obtained in normal controls: 6.9 ± 1.0%. However, obese patients exercised at a higher percent of the maximal heart rate (79% in the obese subjects vs 70% for normal controls). Due to a less efficient walking economy during treadmill exercise, VO2 (expressed per kg body mass) during submaximal exercise was slightly higher in the obese (22.3 ± 2.7 ml O2/min/kg) compared to the normal controls (20.2 ± 2.4 ml O2/min/kg) (P < 0.05).

Conclusion
The similar values for O2 deficit at the onset of exercise in obese patients compared to normal controls shows that there is no evidence of a cardiovascular limitation of exercise capacity in obese patients. Due to a less efficient walking pattern, VO2 during submaximal exercise was higher in the obese patients. Therefore a same absolute work intensity is perceived as more strenuous in obese subjects compared to normal controls.

ASSESSMENT OF CARDIORESPIRATORY EXERCISE FUNCTION IN OBESE CHILDREN AND ADOLESCENTS BY BODY MASS INDEPENDENT PARAMETERS

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Keywords: obesity, exercise testing, pulmonary gas exchange

Introduction
In obese patients submaximal brisk walking exercise may be very difficult to sustain, because of the extra metabolic burden imposed by the excess body mass. Parameters of maximal aerobic exercise performance may be strikingly reduced when expressed per kg body mass. The aim of the present study was to analyse whether cardiorespiratory exercise function is truly impaired in obese children and adolescents, when parameters of aerobic exercise function are used which are independent of body mass. Therefore the kinetics of oxygen uptake (VO2) at the onset of exercise were studied by analysis of the normalised oxygen deficit.

Methods
The patients underwent square wave exercise testing on a treadmill. All patients were compared to a group of 18 normal controls. Body mass was 40.4 ± 10.6 kg (P < 0.001, vs controls). The similar values for O2 deficit at the onset of exercise in obese patients compared to normal controls shows that there is no evidence of a cardiovascular limitation of exercise capacity in obese patients. Due to a less efficient walking pattern, VO2 during submaximal exercise was higher in the obese patients. Therefore a same absolute work intensity is perceived as more strenuous in obese subjects compared to normal controls.

References

LONG TERM FOLLOW UP OF ATHLETIC CHILDREN AND YOUNG ADULTS WITH CONGENITAL VALVAR AORTIC STENOSIS


University of Colorado Health Sciences Center and Denver Children’s Hospital, Denver, USA

Keywords: congenital valvar aortic stenosis, exercise restriction, sudden death

Introduction
Congenital valvar aortic stenosis (CVAS) is predominantly found in males often with a keen interest in sport. They have normal or increased work capacity and cardiopulmonary function (10). Historically, because of the fear of sudden death, rather severe exercise restrictions for both dynamic and static activities have been imposed. Unfortunately, these restrictions have come during an era when high levels of physical activity were encouraged by pediatric caregivers and participation in sport was encouraged by parents and peers. Consequently, in 1978, our institution devised guidelines for activity and sport for CVAS, and patients have been followed closely since that time.

Methods
Starting in 1978, patients with mild to moderate CVAS were allowed to participate in mild to moderate static sport activity as defined by the Bethesda Task Force (8). Guidelines for activity in the same publication would have eliminated virtually all sports and most activity in an extremely active patient population (5). Consequently, four more realistic criteria were established for our study population of patients with CVAS. These criteria are as follows: 1) cardiac catheterization peak aortic valvular gradient or mean Doppler gradient of less than 50 mm, 2) no greater than mild aortic insufficiency, 3) absence of significant left ventricular hypertrophy, dilation or dysfunction and 4) no evidence of ischemia or sustained ventricular ectopy at rest or with exercise. All patients were followed closely (1-2 visits/year) with his-
tory, physical examination, electrocardiogram (ECG), echocardiography with Doppler evaluation including the peak and mean aortic valve gradients, left ventricular (LV) wall thickness and cavity dimensions, and LV systolic function. Each patient also performed maximal cycle ergometry testing using the James protocol to determine oxygen consumption (VO₂), ECG, and hemodynamic responses to exercise. Cardiac catheterization was performed when indicated. Those patients who underwent successful surgical or interventional cardiac catheterization procedures to relieve aortic valvar obstruction were allowed to return to pre-procedural activity levels within 3-6 months if criteria 1-4 were again fulfilled.

Results
The study group consisted of 144 closely followed patients. The typical male/female ratio for CVAS was noted (101M/43F). All of these patients were quite active during this time and were restricted only from high static activities and sports as defined by the Bethesda Guidelines (5). Eighty six patients underwent 127 CVAS-related revascularization procedures and 74 were returned to pre-procedure activity levels after having met criteria 1-4. During 2716 patient years, no episodes of non-orthostatic vaso-vagal syncope or sudden unexpected death occurred.

Discussion
The natural and unnatural history of CVAS as reported in the 1950's-1970's was discouraging and prompted an attitude of pessimism about long term outlook (1-4, 7). In these series, the incidence of sudden death was in excess of 1% per year. Reports of extreme and sudden death, often associated with exercise, and sometimes with a normal ECG, understandably created an extremely conservative and restrictive attitude about activity and CVAS (9). The second natural history of congenital heart disease, the first prospective study of CVAS, reported a mortality of 0.27% per year but had no official uniform policy among the six participating institutions (6). This historical background culminated in the Bethesda conference guidelines for activity and sport participation (5, 8). However, these guidelines were not based on published prospective data. The study group consisted of 144 closely followed patients. The typical male/female ratio for CVAS was noted (101M/43F). All of these patients were quite active during this time and were restricted only from high static activities and sports as defined by the Bethesda Guidelines (5). Eighty six patients underwent 127 CVAS-related revascularization procedures and 74 were returned to pre-procedure activity levels after having met criteria 1-4. During 2716 patient years, no episodes of non-orthostatic vaso-vagal syncope or sudden unexpected death occurred.

Introduction
The popularity of gymnastics has grown tremendously since the mid 1970s. In gymnastics, the upper extremities are often used as weight-bearing limbs. The wrist is particularly vulnerable to injury since it is excessively and repetitively loaded. Some authors reporting cases of stress injury of the distal radioulnar variance1,2. However, ‘cases’ are usually not representative of the morbidity in the general population at risk, and hence, it is difficult to generalise from case reports. Well-controlled longitudinal studies on elite gymnasts are needed. The aims of this study were: (1) to investigate the variability and evolution of ulnar variance in young female gymnasts followed over a 8-year–period; (2) to evaluate the relationship between ulnar variance, and physical characteristics and maturity status.

Methods
The sample consisted of 16 skeletally immature female gymnasts tested annually between 1990 and 1997 for 7 or 8 test sessions. Over the years the girls evolved from recreational to subtop level gymnasts (15 hours training a week and competing at national competitions). At the start of the study the chronological ages varied between 6 and 13 years. Stature (cm) and Body mass (kg) were measured. Skeletal maturity was estimated based on the Tanner-
Whitehouse II method. RUS-age was determined using the radius, ulna and short bones estimation. Ulnar variance (DIDI) was measured according to the method of Hafner et al. DIDI is the distance from the most distal point of the ulnar metaphysis to the most distal point of the radial metaphysis measured on a hand-wrist X-ray (Fig 1).

**Fig 1: measurement of ulnar variance**

Descriptive statistics were calculated for all variables at all test sessions. The evolution and stability of ulnar variance was analysed by means of inter-age correlations and analysis of variance. Correlation analyses between ulnar variance and the anthropometric and maturational characteristics were executed.

### Results

The descriptive statistics for all variables are presented in table 1. The gymnasts show a mean ulnar variance ranging from -3.4 mm at test session 1 to -6.0 mm at test session 8.

The inter-age correlations range between 0.59 and 0.92 (p<0.01 at r>0.60). The correlations between the somatic characteristics and DIDI were low to moderate and reached only significance at test session 7. No significant correlations were observed between maturational and DIDI (table 2).

Table 1: Descriptive statistics for ulnar variance, somatic and maturational characteristics of female gymnasts (n=16)

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<tr>
<td>Weight (kg)</td>
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<td>50</td>
<td>48</td>
<td>52</td>
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<tr>
<td>Height (cm)</td>
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<td>160</td>
<td>158</td>
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<td>160</td>
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<tr>
<td><strong>Maturational characteristics</strong></td>
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<tr>
<td>BMD (cm²)</td>
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<tr>
<td>Ulnar variance</td>
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F1 → F8 : test session 1 → test session 8

The inter-age correlations range between 0.59 and 0.92 (p<0.01 at r>0.60). The correlations between the somatic characteristics and DIDI were low to moderate and reached only significance at test session 7. No significant correlations were observed between maturation and DIDI (table 2).

Table 2: Correlations between DIDI and somatic and maturational characteristics in female gymnasts at each test session (n=16)

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<tr>
<td>Weight (kg)</td>
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<td>0.23</td>
<td>0.20</td>
<td>0.23</td>
<td>0.20</td>
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<tr>
<td>Height (cm)</td>
<td>0.17</td>
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<tr>
<td><strong>Maturational characteristics</strong></td>
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<tr>
<td>BMD (cm²)</td>
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<td>0.17</td>
</tr>
<tr>
<td>Ulnar variance</td>
<td>0.31</td>
<td>0.31</td>
<td>0.31</td>
<td>0.31</td>
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</table>

F1 → F8 : test session 1 → test session 8; *p ≤ 0.05; **p ≤ 0.01

In figure 2 the evolution of mean ulnar variance (DIDI) of 16 female gymnasts over a 8-year-period in comparison with reference data of Hafner et al. is shown. It is clear that the ulnar variance of the gymnasts can be considered as normal.

Figure 2: Evolution of mean ulnar variance (DIDI) of 16 female gymnasts over a 8-year-period in comparison with reference data of Hafner et al. */** respective DIDI value differs from DIDI value of the previous test session (* p ≤ 0.05 / ** p ≤ 0.01).

### Conclusion

It can be concluded that female gymnasts competing at a subtop level show a negative ulnar variance, which becomes more pronounced over the years when training level increases. Compared to reference data the ulnar variance of the gymnasts can be considered as normal. No significant relationships between ulnar variance and somatic and maturational features can be found for most test occasions, only a significant correlation between ulnar variance and height and weight can be observed.

### References