Determination of the proper intensity of physical activity is very important in movement therapy. The planned movement program has to be individual and adequate to the aim of the training, either in rehabilitation or prevention.
The accurate assessment of physical endurance is performed by the spiro-ergometry test. During the test the patient works against a continuously or gradually raising load (e.g. on cycle-ergometer or treadmill) under continuous monitoring of circulation and breathing. Data of the test can be qualified in relation the reference values according to the age, sex and body weight. Intensity of the training can be determinate in percentage of the maximum oxygen uptake, heart rate or working capacity. In patients especially with heart and lung diseases the intensity of the training should not exceed the anaerobic threshold (AT i.e. the anaerobic board of the metabolism). Different methods are used for determination of the AT, in various healthy and pathological conditions.

In everyday practice simplier and faster methods are used such as age related maximum hearth rate (Fr_{max}) and the residual hearth rate. The Borg scale subjectively measures the training intensity by using a 10 or 20 grade visual analogue scale.
The endurance decreases in various life situations. Reaction to the physical stress the old, or weakened people or the patients suffering from chronic lung disease differ from that of the healthy people. Change occur in the performance of the respiratory and circulatory system, in the efficiency of the energy production, and in the strength and performance of the muscular system

The voluntary apnoea time

The apnoea time (AP time) i.e. subject's voluntary breath-hold time, depends on several factors. The researchers pointed the most important factors were the mechanical factors (lung volumes, mechanics of the breathing), the chemical factors (hypoxemia, hyrercapnia), the involuntary contraction of the respiratory muscles, psychological factors (stress, motivation), and external factors (training, strengthening of the muscles. These factors together determine the AP time in interaction each other. The first studies of the AP time were published in the 50's. They studied the influencing factors of „free diving" time. Only few studies focused on patients. A shortened AP time was found in obese patients in study published in 1987. A high correlation was found between the AP time, the FEV_1 and the dyspnoea in patients with bronchial asthma (1989). A study presented a shorter AP time in heavy smokers, in patients with chronic obstructive lung disease (COPD) and in patients with congestive hearth insufficiency (mean 25 s), compared to other patients (mean 45 s) (1994). A decreased AP time measured in patients with obstructive sleep apnoea was in connection with a high resting carbon dioxide end expiratory pressure (2002).

THE AIMS

The aim of our study was to investigate:

- whether there is a correlation between the AP time, lung function, and working capacity, furthermore a correlation between the AP time and the oxygen uptake, the load, and the maximal ventilation;
- how the investigated correlation are influenced by different pathologies and healthy conditions;
- how the age influence the AP time;
- if the AP time measurement is appropriate for establishing the condition of the patients with cystic fibrosis (CF);
- whether can the cardio-pulmonary fitness be increased significantly around the age of 80 years?
- if the AP time can express the effect of the training in the elderly;
- how the training program influences the correlation between the AP time, lung function and the data of exercise tolerance?

METHODS

Participants

Sixty people took part in this study. They were divided into five groups according to their age, physical activity, and healthy condition:

Group 1: young sportsmen (20) male; mean age 20 yr (18-24)

Group 2: young sedentary people (12) 8 female/4 male; mean age 23 yr (20-28)

Group 3: active middle aged people (8) 5 female/3 male; mean age 44 yr (38-54)

Group 4: healthy elderly people (6) 3 female/3 male; mean age 80 yr (77-83)

Group 5: patients with CF (18) 13 female/5 male; mean age 20 yr (15-31)

Measurements

The body weight and height were measured, and the body mass index was calculated for all participants.

Voluntary apnoea time was assessed followed a maximal inspiration.

Lung function: forced vital capacity (FVC) forced vital capacity in the first minute (FEV_1), percentage of the reference values (FVC % and FEV_1%), and the rate of this data (FEV_1/FVC) were measured.

Exercise test was accomplished on a cycle ergometer by using a progressively increasing load. During the test the electrocardiogram and the hearth rate was recorded continuously. The blood pressure was controlled in every second minute. Oxygen uptake (VO_2) carbon dioxide elimination (VCO_2) ventilation (V_E), working capacity (WC) and the time was measured. AT was determined too. The elderly people evaluated the rate of dyspnoea and leg fatigue on a 10 points visual analogue scale at the end of the test.

Training for the elderly people

The elderly took part in an eight-week training program on cycle ergometer three times a week for 40-50 minutes per day.

Data analysis

The relationships between the AP time and the age, the FVC the FEV_1 the VO_{2AT}, the VO_2max, the V_E, the WC_{AT} and the WCmax were analysed by linear regression analysis and calculation of Pearson correlation coefficients using STATISTICA software. The correlation was investigated according to the age, healthy condition and fitness.

T-test for dependent samples was used to determine the differences between the pre and post training data in the elderly group. A p value of <0.05 was considered significant.

RESULTS AND DISCUSSION

I. Our results showed that the AP time decreased with approximately by half between the age of 20 and 80 yr. Despite of the short interval of assessed age of CF patients (16 yr) negative correlation was detectable too.

II. Beside the decreasing AP time the lung function parameters (FVC, FEV_1) decreased approximately by half as well between 20 and 80 year. A positive correlation was found between the age related volumes of lung function and the AP time in the group of young sedentary people, the elderly people and the CF patients.

III. Based on the results of the literature and our study it seems to be verified that the sedentary, the elderly people and the patients are more sensitive to the changes of the P_ACO_2 and the P_AO_2, and this has a very important role of the determination of AP time and exercise tolerance. The AP time shows a significant correlation with the VO_{2max} VO_{2AT} WC_{max} and WC_{AT} in this population.

IV. There were not significant correlation between the AP time and the data of exercise test or the lung function in the group of active people.

V. The correlation between the lung function and AP time and between the lung function and VO_2 and WC suggests that the AP time can be characteristic to endurance only when the ventilation and the lung volume play significant role in exercise tolerance.

VI. Feeling of dyspnoea has an important role in the AP time similarly to the exercise tolerance, especially when the lung function parameters are restricted. It is verified by the high dyspnoea index measured before the training in the elderly people, and the significant correlation between the lung function and the endurance in the patients with CF.

VII. The exercise tolerance of the elderly people was very low in our study compared with the data of international literature. WE was found that the endurance can increase in the 80 old people after an eight-week training. The change is showed by the raise of the AT time and by increase of the VO_{2AT}, the WC_{AT} and the VO_2max. The WC_{max} and the lung function did not changed significantly but the AP time raised and the dyspnoea index decreased.

VIII. The AP time reflects the change the lung function and the endurance in this age. Significant correlation was found between the AP time and the VO_{2max} and the WC_{max} both before and after the training.

Based on our results the AP time seems to be a good accessory measurement for estimate the physical status of the elderly or sedentary people and the patients with lung diseases. The AP time follow the change in the lung function and the endurance, so it is suitable to control the effect of the training program.

As the AP time decreased with the age in similar degree the lung function, likely that the AP time may be considered a normal value measured in the 80 old people. To determinate the age related reference need to assess a bigger population.

PUBLICATIONS

Nagy E, Feher Kiss A, Barnai M, Preszner Domjan A, Angyan L, Horvath G (Accepted: 2007 Január 20.): Postural control in elderly subjects participating in balance training Eur. J. Appl. Physiol. IF:1,619
Barnai M, Domján A, Varga J, Somfay A, Nagy E, Horváth G (2006): Exercise capacity of the 80 age-old people. microCAD 1-6
Barnai M, Nagy E, Rázsó K, Domján A, Horváth Gy (2006): Az akaratlagos apnoe idő változása az életkor függvényében. Mozgásterápia 15:10-15.
Barnai M, Domján A, Varga J, Somfay A, Jeney K, Sárga N, Verebély B, Horváth G (2006): Az állóképesség fejleszthetősége nyolcvan éves korban. Acta Sana 1: 26-33
Barnai M , Laki I, Gyurkovits K, Angyan L Horvath G (2005): Relationship between breath-hold time and physical performance in patients with cystic fibrosis Eur. J. Appl. Physiol. 95: 172-178 IF: 1,465
Barnai M (2000) Az akaratlagos apnoe idő és a fizikai terhelhetőség összefüggései. Mozgásterápia 3:17-18

Congresses

Barnai M, Nagy E, Rázsó K, Domján A, Horváth Gy (2006): Az akaratlagos apnoe idő és a fizikai teljesítmény összefüggései. SZTE EFK Fizioterápiás Tanszék 15 éves Jubileumi Kongresszus. Április 27-28 Szeged
Barnai M (2005) Az akaratlagos apnoe idő és a fizikai teljesítmény. Magyar Gyógytornászok Társasága V. Kongresszusa. November 17-19 Sopron
Barnai M, Domján A, Varga J, Somfay A, Jeney K, Sárga N, Verebély B, Horváth Gy (2005): Az akaratlagos apnoe idő és a nyolcvan évesek állóképességének vizsgálata. Magyar Élettani Társaság LXII. Vándorgyűlése. Június 2-4. Budapest
Barnai M, Domján A, dr. Varga J, dr Somfay A. (2004) Az állóképesség fejleszthetősége idős korban. Magyar Gerontológiai Társaság Kongresszusa Március 26-27. Szeged
Barnai M, Presznerné Domján Andrea, Verebély B, Jenei K, Boros E, Sárga N. (2003) Kerékpár tréning hatása az állóképességre. Magyar Gyógytornászok III. Kongresszusa. Október 16-19. Szombathely

OTHER PUBLICATIONS

Barnai M. (2007) Pre- és posztoperatív légzésrehabilitáció (könyv fejezet) Légzésrehabilitáció szerk: Lengyel L. Medicina, Budapest
Barnai M. (2003) Aktív expektorációs technikák. (fejezet) Modern fizioterápia a cystás fibrózis kezelésében. szek: Borka Péter, Budapest
Barnai M. Gerencsér Zs. (1999), Fejlődés a belgyógyászati fizioterápiában. SZOTE Főiskolai Kar Általános Szociális Munkás és Gyógytornász Szakának jubileumi évkönye 179 – 181

Kádas É, Rázsó K, Barnai M, Fehérné Kiss A (1999): Az otthoni fizioterápiás ellátás indikációs és kontraindikációs körei. In: Az ápolás menedzselése – „ A segítők együttműködése az ápolásban és a paramedicinális foglalkozások területén" 1999.
Pető Éva British Council – SZOTE Népegészségtani Intézet Szeged: 34-36
Barnai M. (1995) Az asztmás betegek fizioterápiája (könyv fejezet) Az asztmáról, az asthma nurse tanfolyam hallgatóinak; szerk.: dr Rónai Zoltán Kaposvár. 66-75

Book translation:
Kapandji I.A. (trans.: Barnai M): Az ízületek élettana I. A felső végtag. Medicina 2005
Kapandji I.A. (trans.: Barnai M, Fehérné Kiss A): Az ízületek élettana II. Az alsó végtag. Medicina 2005
Kapandji I.A. (trans.: Barnai M): Az ízületek élettana III. A törzs és a gerinc. Medicina 2005

Congresses:

International:
Barnai M, Fehérné Kiss A: Challenges in the development of new education structure in physiotherapy program. COHEHRE Annual Conference 2005 marc 30-april 2 Budapest
Barnai M, Bornemisza É Jankovics A., Somfay A: Correlation between the mobilization of the thorax and the exercise tolerance in COPD 14. International Congress of The World Confederation for Physical Therapy; 2003 jun 7-12. Barcelona
Barnai M, Bán R, Physiotherapy education in Hungary. Rehabilittion Congress 2000 okt. 27-30. Bukarest
Barnai M Laki I, Gyurkovits K: Simple indexes for prediction of the exercise tolerance International Congress of Cystic Fibrosis. 1994 máj. 29- jún. 3. Párizs
Barnai M, Gyurkovits K, Holics K,: Two weeks Camp for CF families in Hungary.18 th European Cystic Fibrosis Conference 1993 máj. 21-26. Madrid
Laki I, Barnai M, Gyurkovits K: Acute Effects of Physioterapy Performed by Flutter or Clini-Jet Techniques. IX. World Congress of Cystic Fibrosis 1992 aug. 19-27. Dublin

Hungary:
Barnai M, Várhelyi G, Nagy E, Nagy E, Horváth Gy: A helyreállási időt befolyásoló tényezők. Magyar Élettani Társaság LXX. Vándorgyűlése, 2006 jún. 7-9. Szeged
Bornemisza É, Presznerné Domján A, Barnai M, Nagy E, Horváth Gy: Medence aszimmetriák és a súlyviselés. Magyar Élettani Társaság LXX. Vándorgyűlése, 2006 jún. 7-9 Szeged

Barnai M: A manuálterápia és az aquaterápiás módszerek kombinációja a protrakciós fejtartás mobilizációjára. SZTE EFK Fizioterápiás Tanszék 15 éves Jubileumi Kongresszus 2006. ápr. 27-28. Szeged
Barnai M: Nyaki gerinc mobilizációs lehetőségek az aquaterápiában. Magyar Balneológiai Egyesület Éves Kongresszusa, 2005. nov. 11-13 Szeged
Sebó K, Légrády P, Barnai M, Rázsó K, Aranyász K, Banka I, Lajis E, Tóth O, Ábrahám Gy, Sonkodi S: Statikus és dinamikus egyensúly vizsgálatok hypertoniás betegeken. A Magyar Hypertonia Társaság XII. Kongresszusa 2004. dec.1-4. Budapest
Barnai M: A mellkas mechanikájának megváltozása mellkasi műtétek kapcsán. A Magyar Tüdőgyógyász Társaság Onkopulmonológiai Szekciójának Konferenciája, 2003 dec. 5-6 Budapest
Zapantis G, Csoka I, Horvath G, Barnai M, Kekesi G, Csanyi E, Penzes T, Eros I: Ketamin klorid tartalmú transzdermális gyógyszerformák formulálása és vizsgálata. Congressus Pharmaceuticus Hungaricus XII. 2003 máj. 8-10. Budapest
Barnai M: Relaxációs technikák a hidroterápiában Magyar Gyógytornászok III. Kongresszusa, 2003 okt. 16-19. Szombathely
Barnai M: Légzésrehabilitációs eljárások COPD-ben SZOTE Tudományos Ülések Bizottsága tudományos ülése 2002 febr. 19. Szeged
Barnai M, Bán R, Bornemisza É: Az edzéselmélet alapelveinek alkalmazása a fizioterápiában. „A mozgás szerepe a Csont- Izület Évtizedében" tudományos konferencia, 2001 november 9 Szeged
Barnai M, Borók B: Rehabilitációs lehetőségek COPD-ben Magyar Gyógytornászok II. Kongresszusa 1999 szept. 2-4. Kecskemét
Hódi Á, Barnai M, Gerencsér Zs: Az akut myokardialis infarktuson átesett betegek korai mobilizációjának lehetőségei és korlátai. SZOTE Tudományos Ülések Bizottsága tudományos ülése 1999. Szeged
Barnai M, Fehérné Kiss A, Varga M: Krónikus vállfájdalom haemiparetikus betegeknél. Rehabilitációs Vándorgyűlés, 1999. Székesfehérvár
Barnai M, Hódi Á: A cisztás fibrózis fizioterápiás kezelési lehetőségei SZOTE Tudományos Ülések Bizottsága Tudományos Ülése, 1999. Szeged
Barnai M: Krónikus lumbális gerinc problémák manuálterápiás kezelése. Manuálterápiás Szimpózium 1999. április 23-24. Budapest
Mészáros Á, Barnai M: Aktív expektorációs technikák Gyógytornász Fórum 1996 Szeged
Barnai M: A légzés mechanika károsodásának okai és következményei krónikus légzőszervi megbetegedésekben Gyógytornász Fórum 1996, Szeged