SHORT THESIS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY (PHD)

Assessment of the effects of breathing exercises on endurance and trunk mobility among healthy young female adults

by Éva Csepregi

Supervisor: Sándor Szántó, PhD, DSc

UNIVERSITY OF DEBRECEN
DOCTORAL SCHOOL OF CLINICAL MEDICINE

DEBRECEN, 2022

Assessment of the effects of breathing exercises on endurance and trunk mobility among healthy young female adults

By Éva Csepregi (MSc degree)

Supervisor: Sándor Szántó, PhD, DSc

Doctoral School of Clinical Medicine, University of Debrecen

Head of the **Examination Committee**: Árpád Illés, PhD, DSc
Members of the Examination Committee: Mária Barnai, PhD
Puskás Andrea Lenténé, PhD

The Examination takes place at: Building „B", Department of Internal Medicine, Faculty of Medicine, University of Debrecen, 15. 12.2022. 12.00

Head of the **Defence Committee**: Árpád Illés, PhD, DSc
Reviewers: Tamás Bender, PhD, DSc
Szilvia Katalin Szamosi, PhD

Members of the Defence Committee: Árpád Illés, PhD, DSc
Mária Barnai, PhD
Puskás Andrea Lenténé, PhD
Tamás Bender, PhD, DSc
Szilvia Katalin Szamosi, PhD

The PhD Defence takes place at the: Lecture Hall of In Vitro Diagnostic Building, University of Debrecen, 15. 12. 2022. 13.00

INTRODUCTION

A sedentary lifestyle is causing university students' physical health to decline world-wide (Bull et al., 2020). Based on a meta-analysis published by Castro et al university students spend 7.29 h per day sitting, based on self-reported data (Castro et al., 2020). Similarly, Lee E. et al. (Lee et al., 2019) found that among Korean university students the mean sitting time was 7.96 h per day, and it was also shown that their stress, anxiety and depression significantly worsened if sitting hours increased. According to a study by Nikitara et al (Nikitara et al., 2021) based on Eurobarometer 2017 data, approximately one- third (36.2%) of adults under 65 were physically inactive in 28 countries in Europe. Subjects with increased sedentary behaviour had higher risks for obesity, cardiovascular dis- ease, diabetes, cancer, hypertension, osteoporosis and osteoarthritis, compared to those who sit less. The World Health Organization's (WHO) recommendation (2020) for healthy adults between 18–64 years of age is at least 2.5–5 h of moderate-intensity aerobic type physical activity or at least 75 min to 2.5 h of vigorous-intensity aerobic type physical activity weekly to prevent the consequences of sedentary behaviour (Bull et al., 2020).

According to the studies sedentary lifestyle and irregular physical activity are common in the general population of developed countries and even more so among young adults. Young adults with low cardiovascular fitness due to irregular physical activity and/or sedentary lifestyle are at a higher risk for cardiorespiratory diseases (Siddiqui et al., 2010; Morrell et al., 2013; Subramanian et al., 2013; Racette, 2014). The low cardiovascular fitness and functional imbalance between muscles in agonist-antagonist relation, the decreased range of motion, the decreased chest expansion can be experienced among them. Some of the consequences of sedentary behaviour are postural disturbances. Functional imbalance in muscles chains, limited chest expansion and joint range of motion can be experienced due to long-term sitting periods and a sedentary lifestyle. The unequal loading of joint surfaces and muscle imbalance can be higher risks for functional musculoskeletal complaints, pain and indirectly lower cardiorespiratory exercise tolerance among young adults (Huang et al., 2006; Czakwari et al., 2008; Donald et al., 2010; Siminoski, 2011; Deok et al., 2015).

The risk of these disorders may be lowered by the improvement of endurance performance (Powers et al., 2012; Lavie et al., 2019). The improvement of endurance is linked to sport activities as part of primary prevention in everyday life. Endurance performance can be influenced by the condition of the respiratory system. Respiratory muscle fatigue caused by loading plays an important role in the limitation of endurance performance. Cardiorespiratory endurance is expected to be positively influenced by training the respiratory muscles (Powers et al., 2012).

The treatment of the functional imbalance between muscles in agonist-antagonist relation by aimed strengthening and stretching can lead to physiological mobility and stability of joints. The improvement in chest expansion by targeted stretching and strengthening exercises of the respiratory muscles may play a role in preventing respiratory problems and achieving a higher level of cardiorespiratory loadability (Powers et al., 2012; Tomaszewska et al., 2014; Kim et al., 2015).

Breathing exercises supervised by physiotherapists as an effective method of respiratory physiotherapy have high priority in the rehabilitation of pulmonary diseases and in the improvement of low loadability and limited mobility (Limongi et al., 2014; Westerdahl, 2015). Nevertheless, there is not enough information available about the effectiveness of physiotherapeutic breathing techniques in the primary prevention of sedentary lifestyle-induced musculoskeletal and associated complaints.

In order to avoid influencing the outcomes and have reliable results homogenous female groups were assessed and compared to each other in our study because of the difference between genders in strength and flexibility. The members of the examined groups were selected from physiotherapist students because the primary emphasis in the activities of physiotherapists is on the effectiveness of movement in the prevention and treatment of musculoskeletal and cardiovascular diseases. In their case it is paramount importance that they set a positive example for people through their lifestyle.

The primary aim of this study was to evaluate the effectiveness of physiotherapeutic breathing exercises with regard to posture, range of motion of intervertebral joints and muscle flexibility compared to the effects of the reliable and popular yoga, Pilates and aerobic interval training as special motion programmes. The other aim of the present study was to evaluate the effectiveness of breathing exercises on physical endurance performance in healthy young female university physiotherapist students compared to the effects of Constant, Fartlek and Interval type aerobic endurance fitness training programmes.

Hypotheses:

We assumed that

- there is a large ratio of sedentary lifestyle and physical inactivity among physiotherapist students. Risk factors of cardiopulmonary and musculoskeletal disorders, such as low aerobic endurance level and decreased muscle flexibility can be experienced among them,

- the ratio of sedentary lifestyle among university students in physiotherapy is less than among university students around the world in general,

- the BE can deliver similar improvements in terms of aerobic endurance as the assessed Constant, Fartlek and aerobic Interval Training programmes,

- the BE can deliver similar improvements in terms of postural deviations, spinal and chest mobility and muscle flexibility as the assessed Yoga, Pilates and aerobic Interval Training programmes,

- regular but not well-structured training programmes are not sufficient for correction, so we supposed that the quality of the training plays as important a role as quantity in the correction and/or maintenance of mobility and musclebalance.

Objectives:

- I wanted to investigate whether the ratio of sedentary behaviour in physiotherapy students is similar to relevantliterature data.

- To examine the endurance level and spinal mobility among physiotherapy students in comparison with the standard reference data of the clinical tests.

- To evaluate the effectiveness of breathing exercises on physical endurance performance in healthy female college students compared to the effects of Constant, Fartlek and Interval type aerobic endurance fitness training programmes.

- I wanted to investigate the effectiveness of physiotherapeutic breathing exercises with regard to posture, range of motion of intervertebral joints and chest and muscle flexibility in female university students compared to the effects of the reliable and popular Yoga, Pilates and aerobic interval training as special motion programmes.

- To compare whether dynamic aerobic exercises can compensate as effectively for sedentary behaviour induced muscle imbalance and decreased flexibility as assessed Yoga, Pilates and Breathing exercise slow motion programmes.

MATERIALS AND METHODS

In the present study, we examined full-time undergraduate female students at the Department of Physiotherapy, Faculty of Public Health, University of Debrecen (UD). Students voluntarily participated after an online invitation and were randomly assigned to one of the short-term training programmes.

Inclusion criteria was that participants can be only full-time undergraduate female students of UD. The students had to be willing, available and able to perform the assessments and tests at the specified time. Failure to participate in follow-up (participant did not complete a sufficient number of intervention training sessions or did not return for post-intervention testing) and lack of signature on informed consent resulted in exclusion from the study. Exclusion criteria was that students could not perform any other type of training during assessed period in order to exclude the influence of other training methods.

More than one absence form chosen training program. Participants could not participate in any of the training programmes known to and/or practised by them previously. Students with knowledge of breathing physiotherapeutic techniques could not participate in the targeted BE programme.

The participating students could not have any diagnosed spinal or other musculoskeletal problems, internal organ or cardio-respiratory diseases. These exclusion criteria were assessed based on self-reporting before the intervention. Further exclusion criteria were any symptoms that might have influenced the results of the study, such as body mass index over 29.9 kg/m^2 was considered, abnormal fat mass around the area of thoracic and lumbar spine, pain or inflammation of joints and unstable standing capability due to pain.

According to the randomized selection altogether 61 healthy females (aged 20-22) volunteered to participate in the spinal and chest mobilization programme and 69 healthy females (aged 20-22) volunteered to participate in the endurance programme. Altogether six motion programmes were provided for 100 participants.

Students voluntarily participated to endurance training programme (n=69) mean age 21.2±1.18 year) could be randomly assigned to Breathing exercise programme (BE) and three other fitness training programmes (Constant (CT), Interval (IT) and Fartlek (FT)),

Students voluntarily participated to spinal and chest mobilization programme (n=61) mean age 20.5±1.20 year) could be randomly assigned to Breathing exercise programme (BE) and Yoga, Pilates and Interval training programmes. Students of BE and IT groups were assessed in both programmes.

The four programmes were conducted simultaneously but on different days of the week. All assessments were carried out at the same time of day, before and after the training period. All tests were measured by the same experienced physiotherapist (author), assisted by two further physiotherapists in controlling the measurements in order to avoid measurement errors.

Outcome Measures by Standardized Clinical Tests

Anthropometric data

The anthropometric data of students (age, height, weight, BMI index, body fat %) were assessed in order to compare the groups with each other only before the intervention.

The weight was measured by digital scale and the height was measured by cm tape. Body fat and BMI were calculated only before the intervention using the OMRON Body Fat Monitor BF306 type handle device. Sport activity and physical health and smoking habits were assessed by questionnaire. The number of sitting hours was calculated based on self-reporting only before the intervention. The self-reported data collection was used by oral questioning in our study.

Methods for measuring the effects of endurance training programmes

The Cooper Fitness Test

The Cooper test is known as a reliable field test used for measuring endurance performance. It is based on the close correlation between the maximal oxygen consumption and a 12- minute-run performance. Six categories of cardio-respiratory fitness level (poor, fair, average, good, excellent, superior) are determined according to distance, gender and age. The participants were instructed to cover as much distance as they could in 12 minutes according to their individual physical condition. The test was performed before and after the training period on a 400 m outdoor jogging track. Increased distance represents improvement of this parameter (Weisgerber et al,, 2009; Crystal, 2014; Bandyopadhyay et al,, 2015).

Voluntary breath-holding Time Test

The voluntary breath-holding time is determined by the ability of breath-holding as long as possible in seconds. The breakpoint of voluntary breath-holding occurs when the individual is not able to hold his/her breath any more. Subjects were asked to sit comfortably and were required to make maximal expiration followed by maximal inspiration and to hold their breath as long as possible by using nose clips. This procedure was repeated three times and the best value was used. The rest period between the three breath-holding time tests was 5 minutes. The parameter was measured before and after the training period. This parameter reflects the endurance power of the respiratory system as well as the functional condition and load tolerance. Increased rate represents improvement of this parameter (Barnai et al., 2005; Woorons et al., 2008; Inoue, 2009).

Pulse Control

Individual endurance performance can be determined by maximal oxygen intake. The change of heart rate due to loading may correlate with the rate of oxygen consumption (Powers és mtrsa, 2012). The HRmax was determined by (220–age) equation according to Karvonen. Load intensity can be determined by using the values of resting pulse, the Karvonen formula and pulse control during training. Adequate „own-zone" loading (a safe individual exercise zone) and planned target heart rate training zone may be applied to the abovementioned methods. The rate of general thresholds can change individually. Pulse control was carried out during the fitness trainings when the participants were instructed to measure their radial artery pulse for 15 seconds and multiply the result by 4. (Ángyán, 2005; Sérgio et al., 2008; Powers et al., 2012).

Methods for measuring the effects of spinal and chest mobilization programmes

Assessment of Chest Expansion

The participants were asked to be in standing position with their arms along their body. The participants being examined were asked to stand in a stable position while the circumference of their chest was measured at the level of the axilla as lower chest expansion shows a higher measurement error than the upper (Debouche et al., 2016). The tape was slowly encircled around the chest and the position was continuously under control during measuring to avoid measurement error. The participant was asked to inhale slowly through the nose and to expand the lungs as much as they could. In the second phase, they were asked to exhale the air completely through the mouth. The participant had to stay in apnoea for 2 - 3 s to allow for measurements by the examiner. The measurement was taken at the maximum point of exhalation and inhalation. The difference between the two rates was calculated. The assessment was repeated one more time and the better rate was used. The greater the mobility of the chest, the greater the difference. The average value of chest expansion for a healthy adult is over 3 cm jelzi (Magee, 2013; Clarkson, 2000).

Schober's Test

This test provides information about the range of motion of flexion of the lumbar spine. The participants were asked to stand in an upright position. After the palpation of posterior superior iliac spine on both sides, the level of spinous process of the S2 vertebra was marked and with a measuring tape a 10 cm distance upward was measured and also marked. In order to avoid measurement error, the participants were asked to bend forward slowly as far as they could with straight lower limbs without tilting their pelvis. The distance between the two marked points was measured again. We can obtain an estimate of lumbar spine flexion by calculating the difference between the rates of the two measurements. Normally the distance is 15–17 cm so lumbar flexion is 5–7 cm. If the rate is lower than normal, this can be a consequence of the decreased flexibility of the paravertebral muscles and limited range of motion of the intervertebral joints in the lumbar region (Clarkson, 2000; Norkin, 2009).

Occiput-to-Wall Distance Test (OWD)

This test provides information about the posture of the participants by measuring the position of the head and neck to the trunk, a simple tool for screening and monitoring to determine the presence of thoracic hyperkyphosis. The results are influenced by the rate of spinal curvatures in sagittal plane; thus, OWD is also affected by the rate of thoracic kyphosis and lumbar lordosis. In an optimal situation the occiput touches the wall while the participants stand with their head in a neutral position. If it does not touch the wall, the distance between the wall and the occiput is measured. In order to avoid measurement error, the participants were under strict control while standing with their back against a vertical surface (wall), their heels and buttocks touching the wall in their normal standing position. The participants were standing with their head facing forward and their knees extended as much as possible. The distance between the occiput and the wall was measured by a tape. The measurement was repeated three times with a period of necessary resting. The best of the three measurements was used for the data analysis. A distance below 4–5 cm between the occiput and the wall is normal. Pre-positioned posture is defined as an OWD > 5.0 cm. If the distance is larger than normal, it can be a consequence of increased thoracic kyphosis or a head thrust forward which is due to increased lumbar lordosis. Decreased distance represents improvement of this parameter (Heuft-Dorenbosch et al., 2004; Wiyanad A et al., 2018).

Fingertip-to-Floor Test

This test can be used to measure flexibility of the hamstring muscle group and mobility of the thoracic and lumbar spine. Participants were asked to bend forward as far as they could with their stretched and closed knees, and to try to touch the floor slowly under strict control to avoid measurement error. Optimally the participants were able to touch the floor with their middle fingers. If they could not, the distance between the tip of the middle finger and the floor was assessed. Decreased distance means improvement of this parameter (Clarkson, 2000; Norkin, 2009).

Trunk Side Bending (Lateral-Flexion) Test

The rate of trunk side bending, the harmony of motion and symmetry between both sides are measured using this test. For the assessment of trunk lateral flexion, the participants were asked to stand with their backs against a vertical surface (wall), heels and buttocks touching the wall. They were asked to slide down their hands along their thighs during bending to the left and then to the right side. In order to avoid measurement error, they were under strict control during measurement when they were asked to perform large trunk lateral flexion slowly but as much as they could to the right and then to the other side without rotating their trunk forward and elevating their heels from the floor on the opposite side during trunk lateral flexion and they had to keep their shoulders against the wall. The distance between the tip of the middle finger and the floor was measured in lateral flexed position. There is no normal value. Decreased distance means improvement of this parameter. The test was taken on both sides. The difference between the rate of right and left side lateral flexion was also analysed. If it is larger than 2 cm, it may be due to functional deviations (e.g., quadratus lumborum muscle imbalance) or structural deformities (e.g., scoliosis) in the background. Decreased distance means improvement of this parameter (Clarkson, 2000; Norkin, 2009).

Applied Training Programmes

To compare their effectiveness, we used a breathing exercise programme and 5 different exercise programs. Exercise programs have small numbers of participants in order to achieve the optimal training effects.

Breathing Exercise (BE) Programme (n=15)

A breathing exercise programme is a physiotherapeutic motion therapy in which respiratory muscle training, relaxation techniques, breathing techniques, e.g., deep breathing, hand controlled abdominal/diaphragmatic breathing, aimed stretching and strengthening exercises are combined with each other (Limongi et al., 2014; Westerdahl, 2015).

Deep breathing, controlled diaphragmatic breathing, slow relaxed exhalation with pursed lips technique, direct apnoea exercises for 2 or 3 s and segmental breathing techniques with hand control on chest and/or abdomen were used. Segmental breathing technique was used for the ventilation of the basic part of lung tissue with hand control. Active cyclic breathing technique was applied as a combination of the learned techniques: all phases of respiration were guided (deep inhalation, keeping the air in for 2 or 3 s, slow exhalation with pursed lips and having a deep sough at the end). The aims of breathing exercises were to ventilate all parts of the lung and consequently improve gas exchange by abdominal breathing techniques. The primary aim of using breathing exercises against resistance was to strengthen the respiratory muscles. The stretching exercises were used to maintain and improve the flexibility of the diaphragm. Relaxation was applied during the warm-up and cool-down exercises in order to reduce stress. Exercises were performed in different positions on the floor: lying-, crawling-, and sitting positions. Quiet music for relaxation were played during the exercises. The programme aimed at optimized oxygen consumption and achieving a more effective breathing technique fejlesztése (Birkel, 2000; Grieco, 2014; Limongi et al., 2014; Westerdahl, 2015). The breathing exercise programme was supervised by physiotherapist (author).

Endurance training programmes

Constant Training (CT) Programme (n=22)

Aerobic, low-impact, and cardiovascular trainings were provided in which the intensity was between the 65-70% of HRmax during the work-out phase. The exercises were carried out on a special sport equipment, a step training workout stepper (step bench) at low or moderate intensity. The height-adjustable platforms make it possible to perform the basic moves of aerobics involving stepping up and down. We endeavoured to keep the intensity achieved at the end of the warm-up exercises. (Roberta, 2001; Fatma, 2011; Powers et al.,2012). The programme was supervised by fitness aerobic instructor (author).

Interval Training (IT) Programme (n=17)

Interval training is a special aerobic training in which low and high intensity periods vary in the ratio of 3:1 (6:2 minutes). The intensity was 65-70% of HRmax during the active resting period and 75-80% of HRmax during the high intensity period. In the active resting period low-impact low intensity exercises were performed to improve the cardiovascular system and low-impact high intensity exercises were carried out to improve strength-endurance in the high intensity period. The resting period was performed together in one group while the high-intensity exercises were performed in small groups on stages. Similar kinds of aimed strengthening exercises were performed for the muscles of the anterior, posterior, lateral and spiral muscle chains of the shoulder girdle, trunk and pelvis girdle in the same lying and crawling positions as the ones used during the BE programme, but especially dynamically in the high-intensity periods. (Daussin et al., 2008; Powers et al.,2012). The programme was supervised by fitness aerobic instructor (author).

Fartlek Training (FT) Programme (n=15)

Fartlek or „speed-play" is a special high intensity aerobic training in which low and high intensity periods vary in different ratio. The intensity was 65-70% of HRmax during the active resting period and 75-85% of HRmax during the high intensity period. In the active resting period moderated intensity exercises were performed to improve the cardiovascular system and high-impact high intensity exercises were carried out to improve strength-endurance in the high intensity period. The exercises of the resting and high intensity periods were performed together in one group. (Mercer, 2003; Powers et al.,2012). The programme was supervised by fitness aerobic instructor (author).

The training programmes were conducted simultaneously but on different days of the week. in the gym of Department of Physiotherapy. The training programmes were performed twice a week for one hour per occasion for 7 weeks. There was not any other program provided for them that used breath control in order to exclude theirs influence. The participants could perform that training which was used by them in advance only during the assessed period. The rhythm of the music was between 133-136 bpm during the fitness training programmes.

Spinal and chest mobilization motion programmes

Yoga (Y) Programme (n=16)

Yoga is not solely a physical activity; it is a special philosophy of life containing traditional elements of Hinduism such as moral and ethical precepts. It is a combination of physical, mental, and spiritual practices or disciplines from ancient India. Yoga involves special positions (poses) to strengthen the muscles and to maintain well-being, it is also a spiritual philosophy, with the guidance of the master, repetitions of mantras, the regulation of respiration, and meditation by relaxation making it a self-analysing way of life focused on perfecting one's self physically, mentally and spiritually (Meier et al., 2021). The participants were instructed to concentrate on their respiration in their own rhythm while keeping the achieved poses. The different type of respiration such as diaphragmatic breathing, breathing to intermediate segments and upper segments of lung tissue are separated during yoga exercises. The yoga training contained predominantly exercises for the mobilisation of the trunk and pelvis muscles in order to improve chest mobility, muscle strength and flexibility (Birkel et al., 2000; Pavlik, 2011; Noggle et al., 2012; Kuppusamy M et al., 2017). The yoga programme was supervised by an experienced yoga instructor.

Pilates (P) Programme (n=15)

Pilates is a complex motion which contains the anatomical knowledge of "West" and the movement culture of "East". The Pilates method, designed by Joseph H. Pilates, has 6 principles: strengthening and stabilising the centre of the human body, improving the breathing techniques, concentration, mind control, flowing the exercises into each other, and a slow and correct exercise performance. The training part focused on aimed strengthening and stretching of trunk and hip muscles due to predominantly trunk flexion and extension and rotation in order to improve the mobility of the spine. During the performance of the exercises the basic principles of the Pilates method were in the focus. Concentrating on inhalation and exhalation was combined with relaxation and targeted strengthening or stretching exercises but special breathing techniques such as active cyclic breathing technique or sniff breathing and pursed lips exhalation techniques, etc. were not applied. The participants had to perform the movements in conjunction with breathing (Geremia et al.,2015; Valenza, 2017; Eliks et al., 2019). The Pilates programme was supervised by an experienced Pilates instructor.

Interval Training (IT) Programme (n=15)

The previously presented Interval training is a dynamic special aerobic endurance training in which low and high intensity periods vary in a previously determined ratio. The participants were assessed by tests for measuring endurance level and spinal and chest mobility also but during assessment of mobility 15 participants were possible measured. The strengthening exercises were performed for the same muscles of the shoulder girdle, trunk and pelvis girdle in the same lying and crawling positions as the ones used during the BE programme, but especially dynamically in the high-intensity periods.

The four training programmes were performed twice a week, one hour per occasion, for 7 weeks. The organization and implementation of the surveys and programs began in the fall of 2013 and ended in the spring of 2017.

Statistical Analysis

The baseline measurements' data are presented as mean ± SD. The standardized clinical tests' data are presented as medians and interquartile ranges (IQR). The Shapiro–Wilk test was used to check the normality of the continuous variables. Since most of the data did not follow normal distributions, non-parametric Wilcoxon signed-rank test was used to compare medians. The Spearman's correlation analysis was used in order to investigate the correlation between the variables related to the physical examination. The degree of difference between the four groups' baseline condition was determined by Kruskal–Wallis ANOVA. Dunn's post hoc test was carried out for pairwise comparison of baseline and final pairwise differences. The results were considered as significant if the p-value was below 0.05. The data were processed using Microsoft Excel and the statistical analysis of the data and calculation were made using the Intercooled Stata v13 programme (Stata Corp., 2013)

Sample Size Calculation

A priori sample size calculation was performed with a power level of 80% and an α level of 0.05 based on relevant studies (Perret et al., 2001; Fabrice et al., 2003; Calders et al., 2008; Wiyanad et al., 2018). An online invitation was launched among all physiotherapist students in order to recruit the appropriate number of participants. Refusals, exclusions and group size (to ensure proper attention) were also taken into consideration.

RESULTS

Anthropometric data of the participants of endurance training programmes

The four groups had similar mean value of anthropometric data. All of them could be categorized into the „Normal" category (18.5-24.9kg/m^2) based on the mean value of body mass index (BMI), and three groups were categorized into the "Healthy" (21-32.9%) but the IT group was categorized into the "Overfat" category (33-38.9%) based on the mean body fat content (Gallagher, 2000). According to statistical analysis the IT group differed from the other groups in body mass index (BMI) (ANOVA test (p=0.025), based on difference between CT and FT (p=0.043), between CT and IT (p=0.026) and between IT and BE (p=0.015).

Results of the questionnaire about smoking habits and ratio of physical activity

Our findings showed that physical inactivity was widespread in our assessed group. The 48.5% of assessed students did not have any physical activity and 51.52% (n=34) of subjects made sport activity. The 36.2% (n=24) of assessed participants have regular and the 15% have irregular physical activity among them. The long lasting school time per day, the lack of leisure time and partner were dominantly indicated as the most frequent reasons. The most frequent physical activity was "jogging" (60%). According to our results 86% of assessed students did not smoke (smokers were 9 participants). There wasn't any significant difference between the 4 groups in above mentioned parameters.

Results of the Cooper test

Statistically significant improvement was observed in all training programmes. The average rate of improvement was 8.28% due to IT (p=0.002). The average rate of improvement was 7.75% due to FT (p=0.009). The average rate of improvement was 6.01% due to CT (p=0.001). The average rate of improvement was 5.73% due to BE (p=0.027). The endurance performance improved by 16 participants (94%) in the IT group, 13 participants (87%) in the FT group; 17 participants (77%) in the CT group and 9 participants (60%) in the BE group. Stagnation could be observed only by 2 participants (9%) in the CT group.

Fourteen people (82.4%) improved their categorization in the IT group, 11 people (73.3%) in the FT group; 11 people (50%) in the CT group and 6 people (40%) in the BE group. The 58% of the assessed students (n=69) classified into the „average" or above the "average" category before the intervention (41% were „average" and 17% were categorized in above „average" category). These data improved successfully due to the training programmes.

The number of the students in below „average" category was decreased form 29 (42%) to 12 persons (17%), number of students in „average" category was not changed considerably (39%), and number of students in above the "average" category was elevated form 12 to 30 (44%) participants.

Results of the degree of difference between the four groups' baseline condition

There was no significant difference between the four groups in the baseline condition of Cooper test before the training programmes (Kruskal–Wallis ANOVA (p=0.105) and it remained unchanged as a result of programmes (Kruskal–Wallis ANOVA (p=0.462) after the training period.

Results of the Breath-holding (Apnoea) Time Test

Statistically significant improvement was achieved in three groups and not significant development was seen in the CT group. The rate of improvement of the mean voluntary breath-holding time was 15.2% in the FT group (p=0.007), it was 9.94% in the IT group (p=0.025), and 8.45% (p=0.235) in the CT group. The 9.23% improvement was achieved due to the BE program (p=0,021).

Twelve people (80%) improved their results due to the FT training, 14 people (82%) due to the IT training, 13 people (59%) due to the CT training and 12 people (80%) due to the BE program. In the CT group 2 people (9%) showed stagnation while in the FT group 2 people (13%). Relapse was observed in the FT group in 1 person, in the IT group in 3 people, in the CT group in 7 people and in the BE group in 3 subjects.

The mean rates were below 1 minute in the all groups before the interventions, the rate above 1 minute was not achieved due to training programmes.

Results of the degree of difference between the four groups' baseline condition

There was a significant difference between the four groups in the baseline condition of apnoea test before training program (Kruskal-Wallis ANOVA (p=0.041), but this was the result of the significant difference between CT and FT programmes (Dunn post hoc test (p=0.030) and between CT and BE (Dunn post hoc test (p=0.047). The difference was not significant between the four groups after the training period (Kruskal-Wallis ANOVA (p=0.269).

Results of the degree of difference between the four groups' first and final conditions

Significant differences were observed between the before and after values related to the motion programs according to calculation by Wilcoxon signed-rank test (Cooper test (<0.001); Apnoea test (<0.001).

Result of correlation Analysis

The results of Spearman's rank-order correlation showed a small, positive but significant relation between the results of voluntary apnoea test and Cooper test. The result before the intervention (rho=0.3301; p=0.006) strengthened minimally due to the training programmes (rho=0.3457; p=0.004).

Results of spinal and chest mobilization programmes

The BE, Y, and P groups had similar anthropometric mean values, and there were no significant differences between them. The IT group differed from the other groups in body mass index BMI (Kruskal-Wallis ANOVA test (p=0.002), which was the result of the significant difference according to Dunn post hoc test: IT vs Y (p=0.015), IT vs BE (p=0.006) IT vs P (p=0.004)) and in body fat percentage (Kruskal-Wallis ANOVA test (p=0.045), which was the result of the significant difference according to Dunn post hoc test: IT vs P). All groups fell into the "Normal" category (18.5 -24.9 kg/m^2) based on the mean value of BMI, and three groups were categorized into the "Healthy" (21-32.9%) but the IT group was categorized into the "Overfat" category (33-38.9%) based on the mean body fat content (Gallagher, 2000).

Results of the ratio of physical activity and sedentary lifestyle

The physically inactive students accounted for 48.9% of the assessed 61 students. The other 51.1% had different regularity of physical activity, 36.2% of them reported regular weekly sport activity and 14.9% reported only casual physical activity.

The number of sitting hours can be presented based on self-reporting (n=61). According to the answers, the total of sedentary hours was 2 or 3 hours per day in the case of 14.7% of students, 4–6 hours per day in the case of 36.1% of students, and 7 hours or more in the case of 49.2%.

Chest Expansion Results

With respect to chest expansion, statistically significant improvements were observed in all training programmes. The rate of improvement was 52% in the BE group ($p \leq 0.001$). It was 37% in the Y group ($p=0.003$), it was 23% in the P group ($p=0.002$). The 17% improvement was achieved due to the IT program ($p=0.021$).

Chest expansion improved in 14 participants (93%) in the BE group, in 14 participants (88%) in the Y group, in 12 participants (80%) in the P group and in 9 participants (60%) in the IT group. Stagnation could be observed only in 8 participants (BE: 1 participant; Y: 2 participants; P: 3 participants; IT: 2 participants). Relapse was observed in 6 persons (Y: 1 participant; P: 1 participant; IT: 4 participants).

Schober's Test Results

Statistically significant improvements were achieved in three groups, but no significant development was seen in the IT group. The rate of improvement was 6.3% in the BE group ($p=0.05$), it was 27.8% in the Y group ($p=0.002$) and 25.9% due to P programme ($p=0.003$). The improvement was 4.9% but not significant due the IT programme ($p=0.271$).

The baseline condition of Schober's test achieved the physiological lower limit only in the BE and IT groups (5 cm) but the rate of improvement was greater due to Y and P programmes. The results achieved the physiological lower limit in all groups after the intervention. The greatest mean result was measured due to P programme.

Occiput-to-Wall Distance (OWD) Test Results

Decreased rate represents an improvement in OWD test. Statistically significant improvements were observed in three groups, but no significant development was seen in the IT group. The rate of improvement was 54.7% in BE group ($p \leq 0.001$), it was 73.5% in Y group ($p=0.003$) and it was 77.1 due to P programme ($p=0.003$). The improvement was 2.4% but not significant due the IT programme ($p=0,917$).

Fingertip-to-Floor Test Results

Decreased rate represents an improvement in this test. Statistically significant improvements were observed in two groups (Y, P) and the rates were similar in BE group ($p = 0.056$) but did not change significantly. The mean rates were the greatest before the intervention but relapse was observed in the IT group due to the programme.

The rate of improvement was 65.8% but not significant in the BE group ($p=0.056$). The rate of improvement was 63.9% due to Y programme ($p=0.027$) and it was 66.7% in the P programme ($p<0.01$). Elevated results as relapse was observed in IT programme.

Trunk Side Bending (Lateral Flexion) Test Results

Results of Trunk Side Bending (Lateral Flexion) to the right side

When lateral flexion towards the right side was assessed, statistically significant changes were found in two groups (BE and IT). The rate of improvement was not significant in the Y and P groups. The rate of improvement was 8.86% in the BE group ($p\leq0.001$) and it was 5.27% due to IT programme ($p=0.014$). The improvement was 3.5% but not significant due the Y programme ($p=0.254$) and it was 3% but not significant in P group ($p=0.136$).

The side bending to the right improved in 12 participants (80%) in the IT group, in 9 participants (56%) in the Y group, in 9 participants (60%) in the P group and in all participants in the BE group. Stagnation could be observed in 1 participant in IT; in 1 participant in Y and in 3 participants in P group. Relapse was observed in 11 persons (IT: 2 participants, Y: 6 participants, P: 3 participants).

Results of Trunk Side Bending (Lateral Flexion) to the left side

With respect to lateral flexion to the left side, statistically significant improvements were achieved in three groups (BE, IT and P). The rate of improvement was not significant in the Y group. The rate of improvement was 8.32% in BE group ($p=0.001$) and it was 4.74% due to IT programme ($p=0.019$). The rate of improvement was 4.69% in P group ($p=0.031$). The improvement was 5.3% but not significant due the Y programme ($p=0.156$).

The side bending to the left improved in all participants due BE programme. The results were improved in 10 participants (66%) in the IT group, in 10 participants (62.5%) in the Y group and in 9 participants (60%) in the P group. Stagnation could be observed in 2 participants in IT and in 3 participants in P group. Relapse was observed in 12 persons (IT: 3 participants; Y: 6 participants; P: 3 participants).

Results of the degree of difference between the four groups' baseline condition

There was a significant difference between the four groups only in the baseline condition of OWD test before training program (Kruskal-Wallis ANOVA ($p=0.009$), but this was the result of the significant difference between BE and IT programmes (Dunn post hoc test (p=0.004). The difference was significant too between the four groups (Kruskal-Wallis ANOVA (p=0.001) after the training period.

Results of the degree of difference between the four groups' first and final conditions

Significant differences were observed between the before and after values related to the four motion programs according to calculation by Wilcoxon signed-rank test (Schober I test, OWD test, Lateral flexion, Chest expansion $p<0.001$; Finger-tip-to floor test $p=0.001$).

Result of correlation Analysis

The Spearman's correlation analysis was used in order to investigate the relation between the variables related to the physical examination. Three significant relations were found:

The results of Spearman's rank-order correlation showed a small, negative but significant relation between the results of Schober's test and the occiput-to-wall distance test (rho = −0.2716; p = 0.002).

The results of Spearman's rank-order correlation showed a small, negative but significant relation between the results of fingertip-to-floor test and the chest expansion (rho = −0.1915; p = 0.035).

The results of Spearman's rank-order correlation showed a small, positive but significant relation between the results of fingertip-to-floor test and the occiput-to-wall distance test (rho = 0.3696; p < 0.001).

DISCUSSION

According to previous studies the sedentary lifestyle and its negative physiological effects are civilizational hazards in developed countries, and results of them are in harmony with our results and these findings correspond to our results as well. According to previous research the physical activity of college students is declined in the first transition period of adulthood, especially in the first college year. This may result in college students being more susceptible to chronic diseases (Birkel et al., 2000; Donath et al., 2014; Zheng et al., 2014).

Breathing exercises supervised by physiotherapists as an effective method of respiratory physiotherapy have high priority in the rehabilitation of pulmonary diseases and in the improvement of low loadability and limited mobility of patients. Nevertheless, there is not enough information available about the effectiveness of physiotherapeutic breathing techniques in the primary prevention of sedentary lifestyle-induced musculoskeletal and associated complaints. The primary question of our study was that physiotherapeutic breathing exercises can be similar effective alternative in primary prevention to improve endurance performance, muscular flexibility, spinal and chest mobility in healthy young adults as in rehabilitation of patients.

Significant changes were achieved by BE in most assessed parameters except in Fingertip-to-floor test ($p=0.056$), while the results of the other programs were variable.

Analysis of results of the endurance training programmes

The results of the Cooper test showed significant improvement in all training groups. The mean of the voluntary breath-holding time test showed statistically significant improvement in three groups and not significant development was seen in the CT group.

Findings of the present study showed that the fitness level of the examined college students ($n=69$) was low, 42% of the participants (29 participants) could not even reach the „average" fitness category and only 17% (12 students) had „good" or higher fitness level.

Barnai et al examined the apnea time in pulmonary patients (min 10 sec (VO_2 7,3 ml/kg/min); max 58 sec (VO_2 28,7 ml/kg/min) and they suggested that longer apnoea time is associated with elevated O_2 consumption and exercise tolerance (Barnai et al., 2005). Fabrice Joulia et al said the application of apnoea time as a training method suggests that it is an effective training method to improve hypoxia tolerance and the tolerance of high intensity exercises sustained by anaerobic energy (Fabrice J, 2003; Woorons et al., 2008). Students as active triathlon athletes were examined. A 104±14 second mean apnoea time was measured before a

3 month long training programme, which result was improved to 155±15 seconds ($p<0.01$) due to the training programme (Fabrice J, 2003).

Our apnoea results in comparison with the results of mentioned studies show low rates in our students (n=69). These results are in harmony with „fair” or „average” categorized results of Cooper test (Apor, 2014).

The FT seems to be more effective in the improvement of breath-holding time compared to other applied programs in our opinion. The reason can be found in the difference of loading intensity. The intensity of FT training (75-85% of HRmax) was the highest. The subjective signs of oxygen deficit and higher heart rate were experienced during FT training. Stricter control was necessary to maintain the targeted pulse rate and to keep the subjects in their aerobic loading zone. The intensity of the CT training was lower and more constant compared to the FT and IN programmes. Nevertheless the mean rate of the improvement (in second and %) during CT training was similar to the results of the other two fitness trainings but this group showed the most diverse individual results, therefore the rate of mean improvement was not statistically significant.

The BE had unexpectedly excellent results. The cardiovascular intensity of BE is low (50% of HRmax) therefore they are not considered as endurance performance trainings. Although the breathing exercises had the lowest rate of average improvement in the Cooper test, the results were significant. Significant improvement was achieved in the apnoea time test. The improvement was similarly significant to the results of the most effective fitness training. The structure of the training and the effects of direct and indirect effect-mechanisms of special breathing techniques can be the reasons for the results.

The correlation analysis shows the relation between the tests’ results and can confirm the effectiveness of a provided motion programme (Viitanen et al., 2000; Heuft et al., 2004). The results of Spearman’s rank-order correlation showed if we improve the endurance performance during Cooper test we can achieve a more optimal rate during voluntary apnoea time.

The results of this study, similarly to some previous studies, suggest that special structured BE therapy, supervised by a physiotherapist consisted of special, slow stretching exercises to improve the flexibility of skeletal, especially respiratory muscles and chest mobility and involved targeted strengthening combined with voluntary apnoea exercises, deep, segmental and controlled abdominal (diaphragmatic) breathing techniques with hand control and relaxation, through which directly and indirectly functional postural deformities may be corrected more effectively along with the correction of muscular imbalance. It can improve the tissue oxygenation, muscle metabolism, and hypoxia tolerance (Zaletnyik-Szántó, 2010; Powers S et al., 2012; Zaletnyik – Lengyel, 2014).

Similarly to our study, Zheng et al examined the effectiveness of Tai Chi Chuan (TCC) on the physical and psychological well-being of college students due to a TCC training program for 12 weeks. The cardiopulmonary function was measured by step-test and assessment of blood pressure and rest pulse. They suggested that the changes of parameters due to intervention may strengthen evidence of TCC for the physical and psychological health of college students (Zheng et al., 2014).

Birkel et al demonstrated the effects of Hatha yoga on vital capacity of college students. Subjects were taught yoga poses, breathing techniques, and relaxation in two 50 minute class meetings for 15 weeks. The study showed a statistically significant ($p<0.001$) improvement in vital capacity (Birkel et al., 2000).

The results of this study, in harmony with previous studies, suggest that a short time training programme may be effective to improve cardiorespiratory endurance performance due to targeted exercises (Fatma, 2011; Mahtab et al., 2011; Donath, 2014; Yamazaki, 2013).

According to our results the improvement of endurance performance among healthy young adults is extremely important in order to prevent cardiorespiratory diseases and a well-structured BE can deliver similar improvements in terms of aerobic endurance as the assessed Constant, Fartlek and aerobic Interval Training programmes in healthy young university students.

Analysis of the results of the spinal and chest mobilization programmes

Our present study also proved that the flexibility of the examined female university students (n=61) measured by the special tests is low. The results of the Schober's test were lower than 5 cm in 24 participants (39.3%) and in 25 participants (40.9%) had complex postural abnormalities reflected by the occiput-to-wall distance greater than 3 cm. The rate of chest expansion at axillar level was lower than 3 cm in 8 participants (13.1%). The difference between the rate of right and left side bending (lateral flexion) in 14 participants (22.9%) was larger than 2 cm. The results of finger-tip-to floor tests suggested that approximately 19 participants (31.1%) had limited range of flexion of the lumbar spine. These findings correspond to our results as well. In our opinion, the improvement of flexibility and chest mobility among healthy young adults is extremely important in order to prevent musculoskeletal diseases.

Czakwari et al. assessed spinal abnormalities among 100 students of the Medical University of Silesia (54 female, aged 20–28, and 46 male, aged 20–29). Postural faults were widespread in the assessed group. The most common of these deformities were lumbar hypolordosis (71.0% (48.1% female and 97.8% male) and thoracic hyperkyphosis (58.0% (53.7% female and 63.0% male), and the prevalence of scoliosis was higher than 50%. However physical activity in the assessed group was high (71%). These findings partially agree with our results as well. Our findings showed that physical inactivity was widespread in our assessed group too. The ratio of physically active students in our assessed group was lower (51.1%). Our results suggest that specific targeted exercises are necessary to compensate for the effects of a sedentary lifestyle. Regular but not well-structured training programmes are not sufficient for correction, so we supposed that the quality of the training plays as important a role as quantity in the correction and/or maintenance of mobility and muscle balance (Czakwari et al., 2008).

Other postural training interventions have also been assessed by Celenay et al. University students were assessed (n=96) aged 18-25) by „spinal mouse" system and different therapies were provided. Celenay examined the effects of different methods on spinal posture and mobility such as electrical stimulation, exercises, biofeedback posture trainer and postural education. Larger lumbar lordosis and decreased thoracal mobility were found among the students which were improved by all applied programs significantly ($p<0.05$) but the active exercises were the most effective in contrast with the other programs in the improvement of thoracal mobility (Celenay et al., 2015).

The BE had unexpectedly excellent results. The BE program was the most effective in improvement of chest expansion and trunk side bending tests (Chest expansion: BE ($p\leq0.001$); Y ($p\leq0.01$); P ($p\leq0.01$) IT ($p\leq0.05$), Lateral flexion to the right: BE ($p\leq0.001$); IT ($p\leq0.01$), Lateral flexion to the left: BE ($p\leq0.001$); IT ($p\leq0.05$), P ($p<0.05$). There was no significant improvement in lateral flexion due to Y programme. The BE was significantly effective in improvement of the results of Schober ($p\leq0.05$) and OWD tests ($p\leq0.001$) similarly to P and Y programmes, and resulted effective but not significant ($p=0.056$) improvement in fingertip-to-floor test (Y ($p<0.05$); P ($p<0.01$). There were no significant improvement in Schober's and OWD tests and relapse was seen in fingertip-to-floor test results due to IT program.

These results may be explained by the structure of the training and the effects of direct and indirect mechanisms of the special breathing techniques. The improvement of trunk and chest mobility were in the focus especially by forced trunk lateral flexion and rotation. Trunk flexion and extension were in the focus dominantly during Y and P programmes in contrast with BE and IT programmes. Static stretching and relaxation techniques played important role in all programmes except in IT. The results of IT could be influenced by the dynamism of the exercises. Our results suggest that exercises to improve postural problems, and correct muscle imbalance should be performed slowly under strict control by an instructor. Effective postural control and improvement in muscle flexibility cannot be achieved by exercises performed dynamically.

According to our results the improvement of spinal and chest mobility among healthy young adults is extremely important in order to prevent musculoskeletal complaints and diseases. According to our results a well-structured BE program directly and indirectly can deliver similar improvements in terms of imbalance between muscles in agonist-antagonist relation, the chest expansion and spinal mobility as the assessed popular Y and P programmes in young adults (Birkel, 2000; Powers et al., 2012; Grieco, 2014; Limongi et al., 2014; Westerdahl, 2015).

The most important results of the study

- The endurance level and spinal mobility among physiotherapy students were examined in comparison with the standard reference data of the clinical tests. Our results seem to confirm our hypothesis because our findings showed that physical inactivity was widespread in our assessed group too. These results are in harmony with the ratio of sedentary hours and physical activity among assessed physiotherapist students. The larger ratio of muscular postural problems and limited joint mobility is a consequence of the larger ratio of sedentary hours and the physical inactivity. According to the results our third hypothesis was not confirmed because the ratio of a sedentary lifestyle was similar in the assessed students of physiotherapy to the university students around the world in general.

- Our present study also proved that the spinal and chest mobility and endurance level of the examined female university students measured by the special tests are low. Risk factors of cardiopulmonary and musculoskeletal disorders, such as low aerobic endurance level and decreased muscle flexibility can be experienced among them.

- The effectiveness of breathing exercises on physical endurance performance is similar in healthy female college students as the effects of Constant, Fartlek and Interval type aerobic endurance fitness training programmes due to indirect effect mechanisms.

- The effectiveness of physiotherapeutic breathing exercises with regard to posture, range of motion of intervertebral joints and muscle flexibility is similar in female university students as the effects of the reliable and popular Yoga, Pilates as special motion programmes.

- The structure of a motion program, the harmony between the aspects of the loading play important role in the improvement of endurance performance, and muscular flexibility too. Regular but not well-structured training programmes are not sufficient for correction. Our results suggest that exercises to improve postural problems, and correct muscle imbalance should be performed slowly under strict control by an instructor. Effective postural control and improvement in muscle flexibility cannot be achieved by exercises performed dynamically.

- According to the results it may be suggested that combined training programs are the most effective in which the endurance exercises are supplemented with breathing exercises. Vertical dynamic endurance exercise program combined with targeted motion therapy and breathing exercises in lying and crawling positions may cause more benefits.

SUMMARY

Worldwide, university students' physical health and posture are declining due to sedentary lifestyle, the rate of physical activity decreases to a large extent among them. As a result, without changing their lifestyle, students can be at higher risk of musculoskeletal and cardiorespiratory diseases.

According to previous studies breathing exercises can give us the possibility of mobilization of patients with reduced aerobic capacity. While various fitness training programs or Pilates and yoga are essentially preventive movement programs that assume physiological body structure, the breathing exercises don't assume this (musculoskeletal system, cardiovascular and respiratory system).

According to our research, we have shown that the breathing exercises improves the condition of musculoskeletal system and joint and chest mobility in healthy young adults. It supports the posture correction, which can reduce the risk of developing musculoskeletal problems. According to present study it can improve, both directly and indirectly, effectively the fitness level in healthy young adults too by improving the tolerance of fatigue of respiratory muscles.

Our study suggests that a breathing exercise programme can be safely used as an adjunct exercise programme not only for patients as it may have primary preventive positive effects on the posture, flexibility and strength of healthy adults too. Physiotherapeutic breathing techniques combined with aimed stretching and strengthening exercises can be used by everyone not only in rehabilitation also in primary prevention as part of cross-training.

However, based on our results, the breathing exercise program is a targeted physiotherapist-specific motion therapy which can be used both in the secunder and tertier prevention of patients but in primary prevention and in case of athletes (e.g. in order to improve breathing techniques of swimmers). Targeted breathing exercise program can support the recovery of patients but it can also provide further development for healthy people. Breathing exercises can improve effectively endurance power and range of motion of joint in case of untrained persons and elderly people or in patients in convalescent phase as well as an optimal complementary program for enhancing performance of athletes by direct and indirect mechanisms.

PUBLICATIONS

UNIVERSITY AND NATIONAL LIBRARY
UNIVERSITY OF DEBRECEN
H-4002 Egyetem tér 1, Debrecen
Phone: +3652/410-443, email: publikaciok@lib.unideb.hu

Registry number: DEENK/126/2022.PL
Subject: PhD Publication List

Candidate: Éva Csepregi
Doctoral School: Doctoral School of Clinical Medicine
MTMT ID: 10038522

List of publications related to the dissertation

1. **Csepregi, É.**, Némethné Gyurcsik, Z., Veres-Balajti, I., Nagy, A. C., Szekanecz, Z., Szántó, S.: Effects of Classical Breathing Exercises on Posture, Spinal and Chest Mobility among Female University Students Compared to Currently Popular Training Programs. *Int. J. Environ. Res. Public Health. 19*, 3728, 2022.
DOI: http://dx.doi.org/10.3390/ijerph19063728
IF: 3.39 (2020)

2. **Csepregi, É.**, Szekanecz, Z., Szántó, S.: The effects of breathing exercises in comparison with other exercise programs on cardiorespiratory fitness among healthy female college students. *J. Sports Med. Phys. Fit. 60* (1), 1-7, 2020.
DOI: http://dx.doi.org/10.23736/S0022-4707.19.09916-X
IF: 1.637

UNIVERSITY *of* DEBRECEN

UNIVERSITY AND NATIONAL LIBRARY
UNIVERSITY OF DEBRECEN
H-4002 Egyetem tér 1, Debrecen
Phone: +3652/410-443, email: publikaciok@lib.unideb.hu

List of other publications

3. **Csepregi, É.**, Szekanecz, Z., Némethné Gyurcsik, Z., Szántó, S.: A légzőtorna szervezetünkre gyakorolt pozitív élettani hatásai.
   Mozgásszervi Továbbk. Szle. 3 (2), 63-65, 2020.
4. **Csepregi, É.**, Szekanecz, Z., Szántó, S.: Mozgásszegény életmód és állóképesség mértékének felmérése és fejlesztése gyógytornász hallgatók körében.
   Fizioterápia. 29 (4), 8-13, 2020.
5. Némethné Gyurcsik, Z., Myburgh, J. A., **Csepregi, É.**, Szántó, S.: Keresztszalag-rekonstrukciós műtét utáni posztoperatív mozgásterápia és rehabilitációs tréning.
   Mozgásszervi Továbbk. Szle. 1 (3), 94-101, 2018.

Total IF of journals (all publications): 5,027
Total IF of journals (publications related to the dissertation): 5,027

The Candidate's publication data submitted to the iDEa Tudóstér have been validated by DEENK on the basis of the Journal Citation Report (Impact Factor) database.

31 March, 2022

ACKNOWLEDGMENT

I am grateful to my supervisor, Sándor Szántó PhD, associate professor, head of the Department of Sports Medicine of the University of Debrecen and Zoltán Szekanecz PhD, associate professor, the head of the Department of Rheumatology of the Institute of Internal Medicine of the University of Debrecen, who created the opportunity to do my research. Thank you for your professional leadership, support, valuable advice and trust.

I would like to thank Judit Zsuga Phd. the Dean of the Faculty of Public Health, University of Debrecen and Ilona Veres-Balajti PhD, associate professor, the head of the Department of Physiotherapy, Faculty of Public Health, University of Debrecen for support, valuable advice and trust.

I would like to thank Attila Csaba Nagy Phd. for his professional help in statistical analysis.

I would like to thank Zsuzsanna Némethné Gyurcsik PhD and Dóra Farkas physiotherapists, for their professional help and encouragement.

Thank you for the cooperation of the physiotherapist students who participated in the study and motion programmes.

I would like to thank the colleagues who contributed to the professional translation work.

I am grateful for the love of my dear mother and sister for always being supported and encouraged in my studies.

I am grateful for the love, help, advice, guidance, words of encouragement of my dear husband, the perseverance and supportive love of my children, and the endless patience of my family.

Reference list

1. Apor P. Dr. Apnoe és úszóedzés-hyperventilatioval, Sportorvosi Szemle 2014.; 55.(4.):139.

2. Bandyopadhyay, A.'Validity of Cooper's 12-minute run test for estimation of maximum oxygen uptake in male university students.', Biology of sport. Institute of Sport, 32(1), pp. 59–63. doi: 10.5604/20831862.1127283.

3. Barnai M, Laki I, Gyurkovits K, Angyan L, Horvath G: Relationship between breath-hold time and physical performance in patients with cystic fibrosis. European journal of applied physiology 2005, 95(2-3):172-178.

4. Birkel DA, Edgren L: Hatha yoga: improved vital capacity of college students. Altern Ther Health Med 2000, 6(6):55-63.

5. Bull FC, Al-Ansari SS, Biddle S, Borodulin K, Buman MP, Cardon G, et al. World Health Organization 2020 guidelines on physical activity and sedentary behaviour. Br J Sports Med 2020 Dec;54(24):1451-1462. DOI: 10.1136/bjsports-2020-102955

6. Calders P, Deforche B, Verschelde S, Bouckaert J, Chevalier F, Bassle E, et al. Predictors of 6-minute walk test and 12-minute walk/run test in obese children and adolescents. Eur J Pediatr 2008 May;167(5):563-568.

7. Castro O, Bennie J, Vergeer I, Bosselut G, Biddle SJH. How Sedentary Are University Students? A Systematic Review and Meta-Analysis. Prev Sci 2020 Apr;21(3):332-343. doi: 10.1007/s11121-020-01093-8 DOI: 10.1007/s11121-020-01093-8

8. Celenay S.T, Kaya D.O, Ozüdogbreve R.A. Spinal postural training: Comparison of the postural and mobility effects of electrotherapy, exercise, biofeedback trainer in addition to postural education in university students. J Back Musculosceletal Rehabil, 2015.

9. Clarkson HM. Head, neck and trunk. Musculoskeletal assessment - Joint range of motion and manual muscle strength. 2nd ed. Philadelphia: Lippincott Williams & Wilkins; 2000. p. 68-77.

10. Crystal Coolbaugh, Anderson IB, Wilson MD, Hawkins DA, Amsterdam EA: Evaluation of an exercise field test using heart rate monitors to assess cardiorespiratory fitness and heart rate recovery in an asymptomatic population. PLoS One 2014, 9(5):e97704.

11. Czakwari A, Czernicki K, Durmala J. Faulty posture and style of life in young adults. Stud Health Technol Inform 2008;140:107-110. DOI: 10.3233/978-1-58603-888-5-107

12. Daussin FN, Zoll J, Dufour SP, Ponsot E, Lonsdorfer-Wolf E, Doutreleau S, et al. Effect of interval versus continuous training on cardiorespiratory and mitochondrial functions: relationship to aerobic performance improvements in sedentary subjects. Am J Physiol Regul Integr Comp Physiol 2008 Jul;295(1):R264-72. DOI: 10.1152/ajpregu.00875.2007

13. DeokJu Kim, MiLim Cho, YunHee Park, YeongAe Yang Effect of an exercise program for posture correction on musculoskeletal pain J Phys Ther Sci. 2015, 27(6): 1791–1794. doi: 10.1589/jpts.27.1791

14. Donath L, Roth R, Hohn Y, Zahner L, Faude O: The effects of Zumba training on cardiovascular and neuromuscular function in female college students. European journal of sport science 2014, 14(6):569-577.

15. Fabrice Joulia, Steinberg JG, Faucher M, Jamin T, Ulmer C, Kipson N, Jammes Y: Breath-hold training of humans reduces oxidative stress and blood acidosis after static and dynamic apnea. Respir Physiol Neurobiol 2003, 137(1):19-27.

16. Fatma Arslan, PhD: The effects of an eight-week step-aerobic dance exercise programme on body composition parameters in middle-aged sedentary obese women International SportMed Journal, Vol.12 No.4, 2011, pp. 160-168

17. Gallagher D, Heymsfield SB, Heo M, Jebb SA, Murgatroyd PR, Sakamoto Y. Healthy percentage body fat ranges: an approach for developing guidelines based on body mass index. Am J Clin Nutr. 2000;72(3):694-701.

18. Geremia JM; Iskiewicz MM; Marschner RA; Lehnen TE; Lehnen AM. Effect of a physical training program using the Pilates methods on flexibility in elderly subjects. Age (Dordr.) 2015, 37(6):119 doi:10.1007/s 11357-015-9856z.

19. Grieco CR, Colberg SR, Somma CT, Thompson AG, Vinik AI.: Acute effect of breathing exercises on heart rate variability in type 2 diabetes: a pilot study. J Altern Complement Med. 2014 Aug;20(8):642-8. doi: 10.1089/acm.2013.0280. Epub 2014 Jul 1.

20. Heuft-Dorenbosch L[1], Vosse D, Landewé R, Spoorenberg A, Dougados M, Mielants H, van der Tempel H, van der Linden S, van der Heijde D. Measurement of spinal mobility in ankylosing spondylitis: comparison of occiput-to-wall and tragus-to-wall distance. J Rheumatol. 2004, 31(9):1779-84.

21. Huang M-H, Barrett-Connor E, Greendale GA, Kado DM. Hyperkyphotic posture and risk of future osteoporotic fractures: the Rancho Bernardo Study. J Bone Miner Res.21:419–23. 2006.

22. Inoue H, Yamauchi K, Kobayashi H, Shikanai T, Nakamura Y, Satoh J, Kohno N, Mishima M, Sasaki H, Hildebrandt J.: A new breath-holding test may noninvasisely reveal early lung abnormalities caused by smoking and/or obesity, Chest,2009 Aug; 136 (2):545-53

23. Kim D, Cho M, Park Y, Yang Y. Effect of an exercise program for posture correction on musculoskeletal pain. J Phys Ther Sci 2015 Jun;27(6):1791-1794. DOI: 10.1589/jpts.27.1791

24. Kuppusamy M, Kamaldeen D, Pitani R, Amaldas J, Shanmugam P. Effects of Bhramari Pranayama on health - A systematic review. J Tradit Complement Med 2017 Mar 18;8(1):11-16. DOI: 10.1016/j.jtcme.2017.02.003

25. Lavie CJ, Ozemek C, Carbone S, Katzmarzyk PT, Blair SN. Sedentary Behavior, Exercise, and Cardiovascular Health. Circ Res 2019 Mar;124(5):799-815.

26. Lee E, Kim Y. Effect of university students' sedentary behaviour on stress, anxiety, and depression. Perspect Psychiatr Care 2019 Apr;55(2):164-169. DOI: 10.1111/ppc.12296

27. Lengyel László Dr. A légzésrehabilitáció elmélete és gyakorlata, Medicina Kiadó, Bp. 2014.

28. Limongi V, dos Santos DC, da Silva AM, Ataide EC, Mei MF, Udo EY, Boin IF, Stucchi RS: Effects of a respiratory physiotherapeutic program in liver transplantation candidates. Transplant Proc 2014, 46(6):1775-1777.

29. Magee David. Thoracic (dorsal) spine, Lumbar spine. Orthopedic Physical Assessment,6th ed.: Saunders; 2013. p. 508-648., 1017-1053.

30. Mahtab Moazzami, Nahid Khoshraftar: The effect of a short time training program on physical fitness in female students. Procedia and Behavioral Sciences 15 (2011), Pages 2627–2630

31. Mercer JA, Branks DA, Wasserman SK, Ross CM.: Physiological cost of running while wearing spring-boots. J Strength Cond Res. 2003 May;17(2):314-8.

32. Morrell JS, Cook SB, Carey GB: Cardiovascular fitness, activity, and metabolic syndrome among college men and women. Metab Syndr Relat Disord 2013, 11(5):370-376.

33. Nikitara K, Odani S, Demenagas N, Rachiotis G, Symvoulakis E, Vardavas C. Prevalence and correlates of physical inactivity in adults across 28 European countries. Eur J Public Health 2021 Oct 11;31(4):840-845.DOI: 10.1093/eurpub/ckab067

34. Noggle JJ, Steiner NJ, Minami T, Khalsa SB. Benefits of Yoga for Psychosocial Well-Being in a US High School Curriculum: A Preliminary Randomized Controlled Trial. J Dev Behav Pediatr 2012:33:193-201.

35. Norkin C.C., White D J. The thoracic and lumbar spine. Measurement of joint motion. 3rd edition 2003. p. 336, 344-345; 348-349; 356-358; 4th ed.: F.A. Davis Company; 2009. p. 365-407.

36. Pavlik G. Élettan – Sportélettan. Budapest. Medicina. 595 p. 2011.

37. Perret C, Poiraudeau S, Fermanian J, Colau MM, Benhamou MA, Revel M. Validity, reliability, and responsiveness of the fingertip-to-floor test. Arch Phys Med Rehabil 2001 Nov;82(11):1566-1570.DOI: 10.1053/apmr.2001.26064

38. Powers, S.K. and E.T. Howley, Exercise physiology-theory and application to fitness and performance, M.-H. Education, Editor. 2004 (p.198,252-253,290-296,310-315,407,432) 2012 (p. 243-245,283-284;317-318;332-333; 354-355;360-361,482-487)

39. Racette SB, Inman CL, Clark BR, Royer NK, Steger-May K, Deusinger SS: Exercise and cardiometabolic risk factors in graduate students: a longitudinal, observational study. Journal of American college health : J of ACH 2014, 62(1):47-56.

40. Roberta Fortea, Giuseppe DeVitob, Niamh Murphyc and Colin Boreham: Cardiovascular response during low-intensity step-aerobic dance in middle-aged subjects, European Journal of Sport Science Volume 1, Issue 3, 2001

41. Sérgio Ricardo de Abreu Camarda1, Antonio Sérgio Tebexreni1, Cristmi Niero Páfaro2, Fábio Bueno Sasai2, Vera Lúcia Tambeiro1, Yara Juliano3, Turíbio Leite de Barros Neto1 Comparison of Maximal Heart Rate Using the Prediction Equations Proposed by Karvonen and Tanaka Arquivos brasileiros de cardiologia,2008

42. Siddiqui NI, Nessa A, Hossain MA: Regular physical exercise: way to healthy life. Mymensingh Med J 2010, 19(1):154-158.

43. Siminoski K., R.S. Warshawski, H. Jen, K-C Lee The accuracy of clinical kyphosis examination for detection of thoracic vertebral fractures: comparison of direct and indirect kyphosis measures; J Musculoskelet Neuronal Interact 2011, 11(3):249-256

44. StataCorp. 2013. Stata Statistical Software: Release 13. College Station, TX: StataCorp LP.

45. Subramanian SK, Sharma VK, A V: Comparison of effect of regular unstructured physical training and athletic level training on body composition and cardio respiratory fitness in adolescents. Journal of clinical and diagnostic research: JCDR 2013, 7(9):1878-1882.

46. Tomaszewska A, Pawlicka-Lisowska A. Evaluation of an influence of systematic motor activity on the body posture of young people. Pol Merkur Lekarski. 2014, 36(215):336-40.

47. Viitanen JV, Heikkilä S, Kokko ML, Kautiainen H. Clinical assessment of spinal mobility measurements in ankylosing spondylitis: a compact set for follow-up and trials? Clin Rheumatol 2000;19(2):131-137. DOI: 10.1007/s100670050031

48. Wiyanad A, Chokphukiao P, Suwannarat P, Thaweewannakij T, Wattanapan P, Gaogasigam C, et al. Is the occiput-wall distance valid and reliable to determine the presence of thoracic hyperkyphosis? Musculoskelet Sci Pract 2018 Dec;38:63-68 DOI: 10.1016/j.msksp.2018.09.010.

49. Westerdahl E: Optimal technique for deep breathing exercises after cardiac surgery. Minerva Anestesiol 2015, 81(6):678-683.

50. Weisgerber, M., Danduran, M., Meurer, J., Hartmann, K., Berger, S. and Flores, G.'Evaluation of Cooper 12-Minute Walk/Run Test as a Marker of Cardiorespiratory Fitness in Young Urban Children with Persistent Asthma', Clinical Journal of Sport Medicine, 2009, 19(4), pp. 300–305. doi: 10.1097/JSM.0b013e3181b2077a.

51. Woorons X, Mollard P, Pichon A, Duvallet A, Richalet JP, Lamberto C: Effects of a 4-week training with voluntary hypoventilation carried out at low pulmonary volumes. Respir Physiol Neurobiol 2008, 160(2):123-130.

52. Yamazaki F, Yamada H, Morikawa S: Influence of an 8-week exercise intervention on body composition, physical fitness, and mental health in female nursing students. J UOEH 2013, 35(1):51-58.

53. Zaletnyik Zita, Szántó Katalin Pulmonológiai fizioterápia, Semmelweis Egyetem, Budapest 2008.

54. Zheng G, Lan X, Li M, Ling K, Lin H, Chen L, Tao J, Li J, Zheng X, Chen B et al: The effectiveness of Tai Chi on the physical and psychological well-being of college students: a study protocol for a randomized controlled trial. Trials 2014, 15:129.