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MOVEMENT IN THE CONTEXT OF JAROSLAV FOGLAR'S BOOKS AND HIS PEDAGOGICAL INFLUENCE

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Submitted in August, 2008

This paper deals with a movement motif in Jaroslav Foglar's books and with the influence of this literature on active experiencing by readers, particularly on a potential increase of their movement activities. Although the results (Jirásek et al., 2007) obtained from the empirical research don't prove any connection at a statistically significant level, we can reasonably assume that such literature for youth plays the role of a real motivational factor.

Keywords: Jaroslav Foglar, instructive literature, movement activities.

JAROSLAV FOGLAR AND HIS ROLE IN PEDAGOGY

Jaroslav Foglar (1907–1999) has belonged among the most popular writers of the literature for the youth in the Czech Republic for many decades. At the present time it is possible to obtain very easily detailed information (unfortunately only in the Czech language) on both Foglar's life (Foglar, 2005a; Zachariáš, 2007; Zapletal, 2007), his social influence (Jirásek, 2007), and a description of the origin and development of all his published works (Nosek-Windy, 1999).

More than one hundred years from this, exceptional in Czech history, personality's birthday, we can initiate a more detailed consideration as to whether Foglar's "instructive literature" is still significant as a contemporary pedagogical inspiration or whether it is a closed stage of history. Let's have a look in detail at several arguments that can prove that the ideas and concrete inspirations included in boys' reading material many decades ago can still be inspiring. Even more, they should be utilized much more structurally and systematically at the time when an evident lack of movement activities is understood as one of the most significant reasons for a decrease of the physical abilities of a growing population and thus an increasing number of illnesses (of the kinetic and cardiovascular systems, such as obesity and others).

Despite the fact that there is a sufficient number of "foglarological" reflections in literature, not only in the form of journal studies, but also the comprehensive works of rather a monographic or collection character (Hojer & Černý, 2000; Jirásek, 2007; Mikulka, 1991; Mrva, 1988, 1990; Pírek, 1990; Polák, 2003; Raba, 2005; Sohr, 1968; Toman, 2005; Urbanová & Matýsková, 1992; Zachariáš, 2007; Zapletal, 2007), we are still missing a purely pedagogical evaluation. Foglar's personal character (the ideal of boyhood, an intensive interest in and substantial experience of nature, fantasy appearing not only in the structure of literary stories, but also in the development of new games and programs, the courage to risk adequately and accept new challenges) came naturally to light in the complex of all his activities. An expressively characteristic aspect for this writer and educator is the fact that he understood all his activities instrumentally – as an instrument of his educational efforts. Whatever activity it was, the scout official, the cooperator or the editor of the journals for youth, the writer of belle lettres as well as instructive handbooks and even the author of comics scenarios, everywhere and always a pedagogical aim at the process of cooperation on the basis of Comenius' "redemption of human things" prevailed. The pedagogical potential of his work is included in the following aspects:

- concentration on a healthy lifestyle, movement activities, physical abilities (we are going to deal with this topic in more details further in the text),
- an interest in nature at the level of its recognition, deep experience and perceiving, stays in the outdoors,
- honesty in actions – starting with the attempt at removing vulgarism from youth's speech expressions to glorifying friendship relations to stressing the point of honesty in any action (for example the spirit of fair play in every played game),
- company collectivity, informal society, members of which can compare themselves to one another, evaluate, influence and contribute to development and, at the same time, to self-development (while putting the stress on the power of friendship, proven by decrees of oaths and unconditional solidarity); this value was maximally realized in the readers' clubs' activities

based on their credence and on the ability of young people to achieve self organization,

- a holistic influence on all personality factors (physical, psychological, social as well as ethical),
- motivation, stressing the point of romanticism, adventures, thrills, the structure of tasks characteristized by their challenge to involve all forces (the principal motto of one long term game was: "Alvarez needs only brave and strong persons!"), i. e. the realization of a flow state, a state full of autotelic experience, balanced between stress and boredom (Csikszentmihalyi, 1996),
- utilization of a game to develop aims of all personality factors (physical abilities, motorics, memory, skills, perception, intelligence and fast thinking, etc.),
- support of traditions, making contemporary time more interesting by means of rituals and ceremonies (badges, diplomas, cards, points in any activity, not only the particular program's one – including tidying up and cleaning).

AN INFLUENCE OF LITERATURE ON ACTIVE EXPERIENCE

Foglar's main interest was included in the challenge, not only to read, but even to experience! He repeatedly draws our attention to the fact that only the person who takes reading as the first degree of effort to change his/her personality, as an opportunity to experience the read topics actively and on their own can really fulfill the instructive literature's intended meaning.

These days, we must also be interested in the fact of whether it is not just historical reading and if the books, which are several decades old, still carry the impulse addressing also present youth in the changed social, political and technical circumstances (development of and easy access to transport modes, computers and communications technologies, etc.).

Readers even say that, reading the books, they were influenced positively by the heroes' actions and they care more about their physical abilities and pay more attention to nature, "above standard readers are said to think more often about themselves, about their position among their friends and about possibilities of their self realization" (Urbanová & Matýsková, 1992, 13).

The adventure not only to read, but to get inspired to experience actively in the form of "hunting 13 little beavers", reaching the windows of "a blue life"[1], club activities at meetings and trips, is the real secret of the unique success of Foglar's books, which is not easy to repeat. This is Foglar's pedagogical mastership which hasn't gotten sufficient space in experts' journals.

Naturally, related to these topics and civilization's being in jeopardy, caused by a lack of movement activities, we were interested also in the question of whether reading this boys' literature can become a motivation for real change in their lifestyle. Whether the author is right, when he announces self confidently: "However, after reading one pedagogically instructive book as my books evidently are – regardless of the disputableness of their literary level, really a new, better, gentler life can start and it really – and again evidently – does, now!" (Foglar, 1964, 161). Foglar makes an effort to create a pedagogical ideal of the boy who is not only honest, polite and ethical, but also "can set himself high targets and can aim at them even at the cost of personal asceticism". It is rather a crucial moment, because, as I think, it is the character in which Foglar differs from the whole range of the writers presenting to youth patterns worthy of being followed, writing about honesty and justice, striving to present and distinguish between goodness and evil. However, to grasp education as a challenge for an educated person himself/herself, i. e. to make education into self education by means of exacting activities requiring all one's personal forces, it is a real phenomenon, that is brought to the literature by the experienced author who lived with boys and spent with them all his time. Therefore he understands them and can make self educational impulses immensely attractive. Otherwise the substance of Foglar's romanticism is the will to act and "the braveness necessary for dynamic self education" (Bösser, 1964, 497). A legend turning a dull task into an adventure, a game attracting by the very uncertainty of the winner, a secret invitation to be discovered – these are instruments and methods that have not been surpassed, probably not even until this time. Martin Hybler draws our attention to the value context of the increase of the typical criminality of the youth at this time (drugs, car stealing, firing weapons/setting fires, using guns, raping, or even torturing) as a result of searching for adventures and stimulation at any cost. It is no wonder that he comes to the conclusion: "Understanding the education of preadolescents, to which Foglar invites us, belongs perhaps to the most important civilization tasks of all" (Hybler, 1999, 42). Foglar's books, popular and read regardless of the change of political and social circumstances, can play (and really do) the role/perform the task of a stimulation impulse to the life self education and self development of young boys, to the more gentle and beneficial spending of leisure time (the insufficient utilization or enjoyment of which is, by the way, the most important factor in the origin of

[1] Two of Foglar's pedagogical instruments serving youth self development: a romantic legend presented together with a set of tests motivating boys to spend actively their leisure time actively. For more details see the next part of this paper.

not only the drug addiction – Mrva, 1988, 1). They add an original and very inspiring stimulation by the form which encourages in its dramatic and mysterious way to independent activities leading to self regulation of his/her own behavior and acting towards the realization of ethically demanding values.

MOTIVES OF MOVEMENT

Perhaps in every Foglar's book we can find an ideal pattern that is presented to the readers to be imitated: a model boy as if according to a pattern, ethically mature, physically able, hard working, conscious of his obligations. In this part we are trying to highlight the main motives accenting the beauty of a sporting body, fast, strong, sun burnt, in short trousers. The bodies are used to daily morning exercises, slim, flexible, full of force, weather proof and healthy. Besides a significant protest against smoking and alcohol there is permanent pressure or motivation to do exercises and sports as well as camping, which we can find in every one of Foglar's books. The following motives are worthy of being mentioned in more detail: the challenge for self knowledge and comparison of forces, represented in the form of stimuli to "hunting little beavers", to finding out whether the reader himself/herself has all 13 features that "the model boy should have", is at the beginning of the book "Boys from the Beavers river" ("Hoši od Bobří řeky") (Foglar, 2003). The legend about the boy Roy growing up in a natural wilderness with his father and even with an old Indian man for a certain time who exposes him to various tests is brought to us by the story about 13 rusty nails being beaten into the log for hanging furs of the hunted beavers. Their hunting is an initiating test proving the turning of the boy into the man. The writer takes this legend as a motivation factor for the development of the test that can be passed in our time (or for many decades since the 1930s when this book was published for the first time). Besides "the little beavers", i. e. the tasks aimed at helping others and a social solidarity (the little beavers of the rescue and good deeds), tests developing courage, patience and willpower (the little beavers of courage, silence, loneliness, hunger), the tasks improving their knowledge of nature (flowers) or polytechnical preparation (skills) and at last, even honesty, goodness and politeness (gentleness), we find even four tests concentrating on physical abilities and a healthy lifestyle here: the little beaver of nimbleness (running, high jump and long jump), aiming (cock shot), swimming and force or strength (pull ups).

Another topic is included in the style of the "blue life", introduced for the first time in the book "The port is calling" ("Přístav volá") (Foglar, 2005b). They are life principles leading to self development, to a gentle life, among which regular everyday morning exercises, at least for a quarter of an hour, belong. A bit different form of the "blue life" is described in the book "Chronicle of the lost footstep" ("Kronika Ztracené stopy") (Foglar, 2001) as seven tasks or obligations (including experienced joys and performed good deeds), where everyday washing in cold water also belongs, besides morning exercises, in the area reflected upon by us.

Despite the fact that it would be possible to mention the notes on individual challenges to movement activities perhaps in every book, for the last example we are selecting a description of a competition in physical skills[2] from the book "Our division" ("Náš oddíl") (Foglar, 1998). It is a set of 42 exercises (forward roll, somersaults, five bent arm rests, knee bend, hand stand, straddle vault, bend forward, jump rope, handspring, climbing a tree, riding a bicycle, swimming, crossing on a log over a brook, jumping over a table, climbing a rope etc.) valued at a total of one hundred points, the right performance of which is checked and confirmed by an appointed "instructor of the exercise".

"Every PE teacher would enjoy it and many camp leaders would surely envy us if they saw how our boys do somersaults, knee bends, bent arm rest, handsprings, handstands or rope jumping and many other exercises with no restraint, with enthusiasm and voluntarily" (Foglar, 1998, 100).

Why is it so? How does it come that at a time in which a lack of movement is perceived as one of the biggest risks of the future of our population, somebody accepts unattractive exercises even with enthusiasm? It is absolutely sure that the growth of motivation to do these activities is decided by the way of their presentation, even of usual activities, as something that serves self knowledge and comparison with others. It means the character of the competition, but also the task presented as a challenge, as an appeal to self involvement: "What is your body like? Every boy's pride is being perfectly grown, flexible, nimble, fast, skilled and strong. The majority of these features can be achieved by everyday regular exercises. The body thus gets not only a better look, but even strengthens its force and skills. Our traditional Competition in Physical Nimbleness (STO) should make you put your winter laziness aside, start doing permanent exercises and persuade yourselves that you are the right boys full of energy and not only lazy home birds, jelly and elephant whelps! Only the boys with a weak will do not participate in our STO and do not make an attempt at taking an honor position. But those who want to look like Indian youth or boys from Ancient Sparta know what to do – try to fulfill as many

[2] In Czech this competition is called "Soutěž Tělesné Obratnosti" – the abbreviation of which is STO which means "one hundred" in Czech.

exercises from our competition as possible. And the honor badge for the physical skills is also a nice prize! Who gets it? Who of the whole division will achieve the most points in STO?" (Foglar, 1998, 101).

However, we can simply object that such challenges and appeals are not very effective, that we have no proof of the effectiveness and force of these topics' fulfillment. Therefore it is the relationship to the movement activities really performed by our readers of Foglar's books that we tried to set as an aim of our partial research.

RESEARCH INTO REAL MOVEMENT ACTIVITIES ON THE BASIS OF READING FOGLAR'S BOOKS

Last year the survey[3] into the relationships between reading Foglar's books and movement activities really performed was carried out (see details Jirásek et al., 2007). Here we will only report on the relationship between the number of the books read and the amount of movement activities performed.

An original intention, i. e. a comparison of readers' movement activities (as the responders expressed through the International Physical Activity Questionnaire IPAQ – long version) with a group of non readers could not be fulfilled: the gained answers (in total 1692) are almost exclusively connected with the knowledge of Jaroslav Foglar and his books (only 4 answers expressed ignorance of the name Jaroslav Foglar, 38 persons had read none of his books). From the results we have come to/drawn the following conclusions: As a motivational instrument for change in their lifestyle, literature has been indicated by the respondents as a relatively significant fact. Readers' belief that, for only 14% of them, reading did not mean any change in experiencing ended up relatively surprisingly. On the contrary, instructiveness of this type of literature is personally proved by significant representation of all observed categories. Although our priority concern was to find its possible influence on movement activity (which has been proved by 21% of the respondents), according to those who read them, Foglar's books have the most significant impact, especially on staying in nature, the adventurousness of experience in a group of contemporaries, and general activity. Wilful agreement with the author's moral appeal, i. e. with readiness to do good turns, has been noted by more than triple the number of readers than of those who were not led to any change by reading. However, our survey could not check whether this declaratively proved impulse has been fulfilled.

We were interested especially in the relationship between reading and amounts of movement activities stated by the respondents themselves.

In order to compare dependency of movement activity on the number of books read, we divided the investigated selection into four groups. Of the total number, 909 persons answered the questions about movement activity. It follows from the results of the table that people who read more of Foglar's books perform more movement activities. However, differences between individual groups are not statistically significant. It is also obvious that in every group there is a high share of an individual's approach to movement activity (high values of standard deviation).

CONCLUSION

We are not going to overestimate the obtained results in any way. However, as we are aware, a real influence of reading belles lettres on change in lifestyle with impact on concrete readers' activities and actions has been investigated neither in the Czech Republic nor anywhere else yet. We consider our survey as the first attempt to interconnect opinions on reading and opinions on lifestyle, particularly the amount of performed movement activity. Although the connection failed to be proved at a statistically significant level, we believe that the results are interesting, especially in the part concerning a traceable relation between the number of Foglar's books read and the amount of movement activity performed.

In other words: respondents' answers clearly show that reading Foglar's books inspires and motivates them to movement activity, and there is obviously even a relationship between the number of books read and the amount of movement activity there is (even if not statistically evidently). At the same time, we believe that, by means of quantitative research methods, we managed to prove (at the level of 1% weight) that this literature inspires its readers significantly to an active lifestyle and deeper experience. However, in no case can we consider the results surveyed by us as a simple line: the more of Foglar's books a person reads, the more he/she moves, even if such a relationship may be indicated by the respondents' answers. The question as to whether the opposite relationship (i. e. whether this type of literature is read by individuals who perform more movement activities) works, was not considered in the research, nevertheless, respondents' statements prove rather the influence of reading on movement activity, not conversely.

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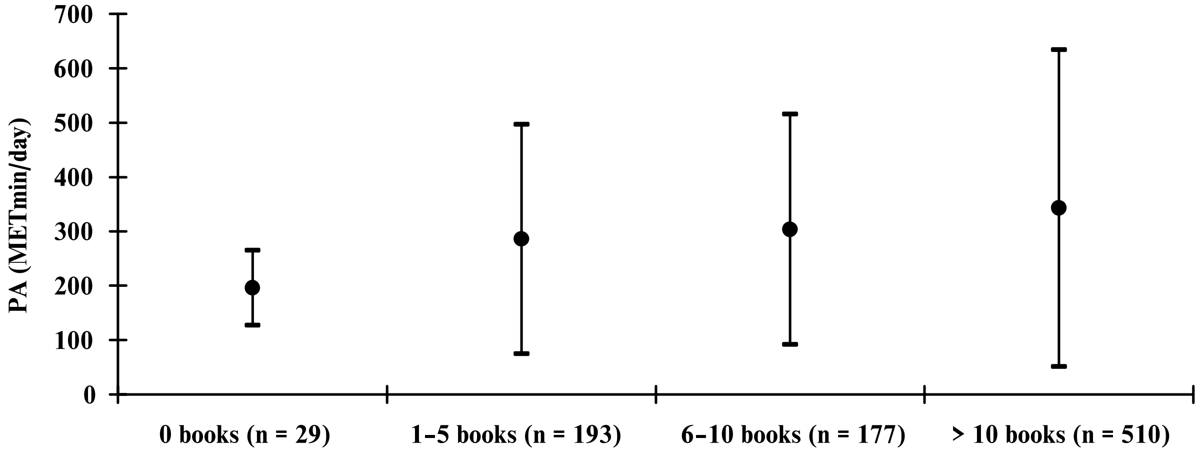
[3] Other co-authors cooperated on this research: M. Elfmark, D. Sigmundová and F. Křen from Faculty of Physical Culture, Palacký University in Olomouc. The author thanks to all of them for their cooperation.

Fig. 1
An average movement activity (MET/min) of the readers of Foglar's books



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POHYB V KONTEXTU DÍLA A PEDAGOGICKÉHO VLIVU JAROSLAVA FOGLARA
(Souhrn anglického textu)

Příspěvek se zabývá motivem pohybu v knihách Jaroslava Foglara a vlivem této literatury na aktivní prožívání čtenářů, konkrétně na potenciální zvýšení pohybové aktivity. Přestože výsledky získané z empirického šetření (Jirásek et al., 2007) nejsou průkazné na statisticky významné rovině, můžeme důvodně předpokládat, že literatura pro mládež hraje roli reálného motivačního faktoru.

Klíčová slova: Jaroslav Foglar, návodná literatura, pohybové aktivity.

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EFFECTS OF COGNITIVE BEHAVIORAL PSYCHOTHERAPY ON BODY COMPOSITION AND CONSTITUTION

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Obesity is a chronic disease of modern times that is not just a cosmetic problem but a bio-social-psychological problem especially, which means that obese individuals have, apart from their medical problems, also social and psychological problems. They often suffer from depression, low self esteem and difficulties in the job market field. The aim of the study was to examine the effect of physical activity and the modification of nutrition patterns on the somatic parameters in STOB courses (the courses for weight loss and obesity reduction) in women at the age of 20–60 years (n = 114).

The standardised anthropometrical methods were used to determine the basic somatic indexes – body weight and height, risk indexes and central obesity indexes, body composition according to Pařízková, and Matiegka and bioelectric impedance methods (QuadScan 4000; Tanita BC 418-MA). Women were divided into the groups according to age decennary. Women were measured at the beginning and at the end of the course, which lasted 12 weeks. STOB courses are led by professionals who are involved not only in physical activity but also in modification of nutrition and food intake patterns. In the groups as a whole, the BMI reached the average values of 31.34 in the initial examination, although the maximal value exceeded the limit of morbid obesity, which is 47.56. On the basis of the BMI categorisation by WHO, only 7.5% of women were in the "standard" category and 57% were obese, of which 5% were morbidly obese. According to the evaluation of subcutaneous adipose tissue using Matiegka methodology, 57.5% had more than 30% fat content, of which 28.75% was in the category of over 40% fat. The values of the centrality index, which are the ratio of the individual skin folds on the trunk and on the extremities and it shows the distribution of fat, reached values from 1.3 to 1.5. These values demonstrate the disproportional distribution of fat, with a dominancy of subcutaneous fat on the trunk. The centrality indexes correlate with WHR values and confirmed the distribution of fat was confirmed, particularly on the trunk part in comparison to the lower extremities – thus we are looking at the abdominal type of obesity. When the course had been completed, all methods used confirmed significant changes – lowering of body weight, BMI and the amount of adipose tissue in all age groups. The evaluation of the average values of circumferential dimensions showed a reduction in waist and hip circumference, in abdominal and gluteal circumferences, and eventually in the lower extremities' circumferences. A significant lowering of the endomorphic component was found in all age categories.

Movement and exercise therapy in combination with changes of dietary regimes within the framework of STOB body weight reduction courses has a nearly 15 year tradition in the Czech Republic and has had significant effects on its clients' somatic condition.

Keywords: Clients of STOB courses, body composition, typology, BMI, overweight, obesity of different grades.

INTRODUCTION

Obesity can be regarded as a chronic disease that is, apart from excesssive body weight and other somatic parameters, accompanied by a range of biochemical, physiological and orthopedic markers (Pikhart et al., 2001; Sammel et al., 2003). According to WHO (BMI, 2004), there is currently more than 1 billion people overweight in the world and more than 300 million are clinically obese. The increasing incidence of excessive weight or obesity among adolescents and children is particularly alarming. In the Czech Republic, every second person is overweight, which is more than 5 million people. The Czechs are one of the most overweight nations in Europe (http://www.merrylinka.cz/nadvaha-a-obezita/obezita-novodoba-epidemie-stoleti.aspx).

Since mid 70^s the prevalence of being overweight or obese has been increasing worldwide. In 20 to 74 year old adults, the obesity prevalence grew from 15% in 70^s to 32.9 % in 2003/2004. The increasing tendency of prevalence has also been observed in children and teenagers: in 2–5 year old from 5.0% to 13.9% and in 6–11 year old children from 6.5% to18.8% and in 12–19 year old from 5.0% to 17.4%.

Obesity is a chronic disease of modern times that is not just a cosmetic problem but also a bio-social-psychological problem especially, which means that obese individuals have, apart from their medical problems, also social and psychological problems. They often suffer from depression, low self esteem and difficulties in the job market field.

Obesity is very often associated with type 2 diabetes mellitus and metabolic syndrome, which is accompanied by insulin resistance, changes in the lipoprotein pattern and elevated blood pressure. Almost all Americans suffering from metabolic syndrome have increased WHR (Stamler, Wentworth, & Neaton, 1986; Folsom, Kushi, & Anderson, 2000).

Obese individuals very often have the following health problems: infertility, pulmonary diseases, hypoventilation, sleep apnea, negative changes in the musculoskeletal system (arthrosis, arthritis, lower joint mobility, changes in the mobility stereotypes, changes in bone architecture), orthopedic disorders, cardiovascular diseases (risk of infarction, ischemic heart disease), blood coagulation disorders, increased risk of cancer, liver problems, and so on (Alexander, Landsman, Teutech, & Haffner, 2003; Ballor & Poehlman, 1994; Craft et al., 1995; Isomaa et al., 2001; Lakka et al., 2002).

Brochu et al. (2001) observed 43 obese post menopausal women with sedentary jobs as to their physiological, physical and metabolic parameters. The women were divided into two groups: 1. metabolically normal (n = 17), 2. metabolically abnormal with insulin resistance (n = 26). These two groups differed in fat free mass, visceral fat, and glucose disposal parameters.

The risk of dementia in people with a BMI above 30 is 35% higher than that in individuals of normal weight. This risk increases by up to 75% in obese individuals (Whitmer, Gunderson, Barrett-Connor, Quesenberry, & Yaffe, 2005).

Regular physical activity is an important component of weight reduction programs as it is related to the long term maintenance of reduced body weight. In addition, it has beneficial effects in particular on cardiovascular diseases and diabetes. It prevents the reduction of basal metabolism and fat free mass (Ballor & Poehlman, 1994; Garrow & Summerbell, 1995; Donnelly, Hill, & Jacobsen, 2003; Donnelly, Kirk, Jacobsen, Hill, & Sullivan, 2003; Wadden et al., 1997).

Studies involving body weight reduction by means of movement and exercise programs plus dietary measures were more successful than dietary measures alone. However, significant differences in body weight loss by means of one or the other therapeutic approach have not always been demonstrated (Bertram, Venter, & Stewart, 1990; Jeffery, Wing, Sherwood, & Tate, 2003; Wing, 1999).

AIM

To determine changes in body composition and constitutional changes in clients of STOB courses based on cognitive behavioral psychotherapy.

METHODS

The standardised anthropometrical methods were used to determine the basic somatic indexes – risk indexes of central obesity and body composition as determined by anthropometrical methods according to Pařízková and Matiegka (in Riegerová et al., 2006) and the fractionalisation of body weight by means of the bioelectric impedance method (BIA – Tanita BC 418-MA, segmental analysis; QuadScan 4000, kg and % fat, kg and % fat free mass, total body water, extracellular body water and intracellular body water – l, %). Women were measured at the beginning and at the end of an STOB course of therapy that lasted 12 weeks and was led by professional trainers.

The STOB courses' target is not only physical activity but also it has a theoretical part, because the reduction of body weight involves the modification of food intake stereotypes and lifestyle (cognitively-behavioural psychotherapy).

A cognitive behavioral unit includes guidance in the area of nutrition, psychological consultancy and movement activity. Women learn how to prepare an eating plan in accordance with healthy dietary principles. They check their energy intake and output and learn to eat food regularly and determine the energy of the individual components of the food. They were advised to reduce their energy intake to 4500 kJ/day. The exercise program is arranged as a 60 minute unit comprising an initial phase (warm up), stretching, aerobic strengthening (40–45 minutes), and a compensatory (relaxation) phase (15 minutes).

We measured 136 women from Olomouc and environs in the Czech Republic from 20 to 60 years old in the initial examination. The final measurements were participated in by 114 women; 16.2% (n = 22) of the women did not complete the course.

The measurements were performed between the 6^{th} of February 2006 and the 10^{th} of June, 2008 in 11 courses led by 4 different trainers. The average age of the women was 41.4 years old.

The age and frequency of clients in the separate age groups: from 20 to 30 years of age (20 years old, n = 19), from 30 to 40 years of age (30 years old, n = 28), from 40 to 50 years of age (40 years old, n = 35), and from 50 to 60 years of age (50 years old, n = 32).

ANTROPO and STATISTICA 6.0 programs was used for statistical processing.

RESULTS AND DISCUSSION

The youngest women seem to be the tallest among the age categories, averaging 169.6 cm in height. Other age categories are at least 5.4 cm shorter. The mean body weight during baseline measurements exceeded 80 kg in all age categories. After completion of the therapy, the mean body weight fell to below 80 kg in the 20 and 40 year olds. Maximum values in all age categories reached more than 100 kg. The highest body weight reduction was observed in the oldest age category. Differences between the baseline and final values of the body weight range from 3.3 to 5.1 kg (ascending with age) (TABLE 1).

The comparison of selected somatic parameters with Czech population parameters is shown on Fig. 1.

Circumference parameters on the trunk decreased in all age categories, however a significant decrease in all trunk circumference parameters (abdominal circumference, abdomen; gluteal circumference, glut; waist, chest mesosternal circumference, OTHM and chest xiphosternal circumference, OTHX) was reached only in the oldest age category.

A significant reduction was observed in the gluteal and gluteal thigh circumference in 20 years old, abdominal and gluteal thigh circumference in 30 years old, and abdominal circumference and body waist in 40 years old (Fig. 2).

Mean BMI values at baseline exceeded 30 units which means a classification as grade I obesity (WHO, 2004). The only exception was the youngest category of women who were "only" overweight. Cognitive behavioral therapy resulted in the reduction of mean BMI values in all age categories (differences between MI and MII with increasing age were as follows: 1.16, 1.46, 1.61 and 1.85). The overweight category was the most frequently determined category during the first measurement among 20 and 30 years old women. More than 50% of the women had grade I obesity among the 40 and 50 year old women. After the completion of the therapy, a significant and positive shift into the overweight category was observed in all age categories (Fig. 3, TABLE 2).

TABLE 1
Average values of body weight and height

AGE	Weight MI (kg)				Weight MII (kg)				Height (cm)			
	M	Min.	Max.	SD	M	Min.	Max.	SD	M	Min.	Max.	SD
20 years (n = 19)	82.2	69.0	109.3	12.2	78.9	65.0	105.0	11.9	169.6	157.0	185.5	6.6
30 years (n = 28)	85.4	62.0	147.0	18.3	81.5	57.5	135.6	17.7	164.2	152.6	177.4	6.5
40 years (n = 35)	84.1	59.0	106.0	11.5	79.6	57.1	100.3	10.9	163.1	153.0	175.2	5.4
50 years (n = 32)	87.0	68.7	106.4	10.6	81.9	63.8	99.5	9.9	163.6	153.0	173.8	5.2

Legend: MI – 1st measurement, MII – 2rd measurement.

Fig. 1
Standardized indexes (z-score) of selected somatic parameters in comparison to the Czech population (Bláha et al., 1986)

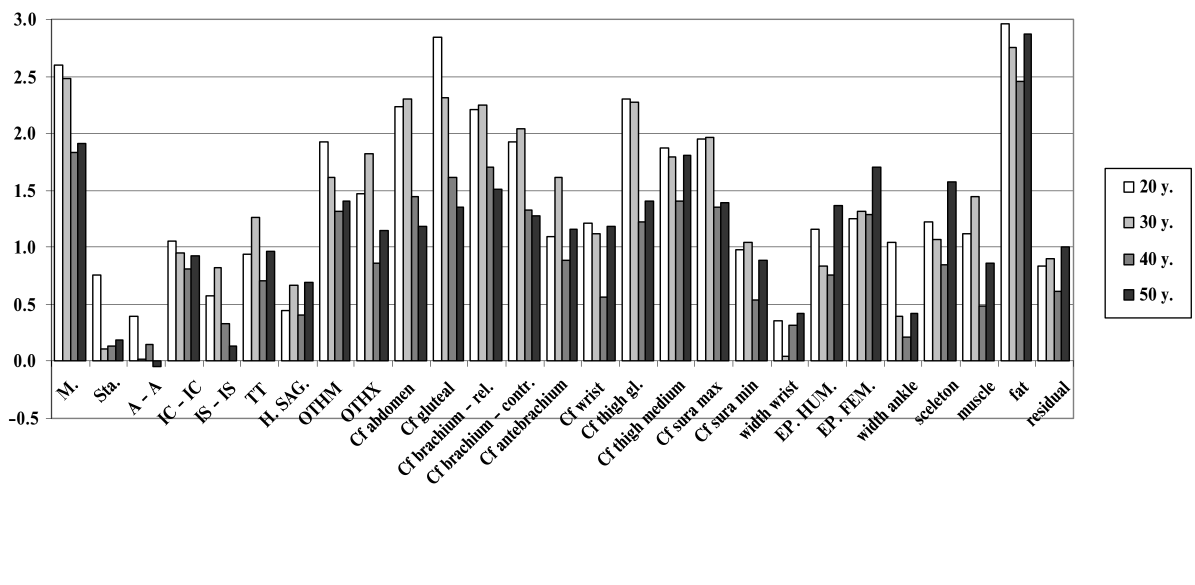


Fig. 2
The changes in the average values of selected circumferential parameters on the trunk

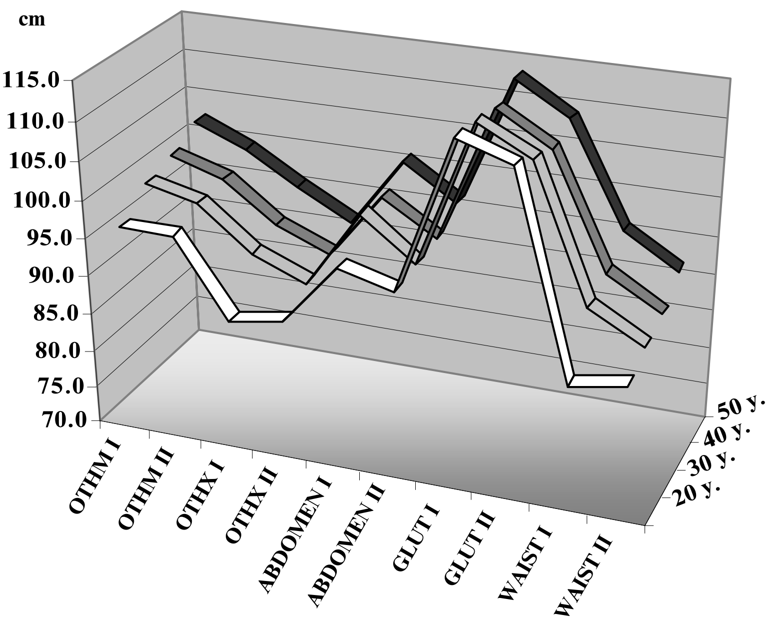
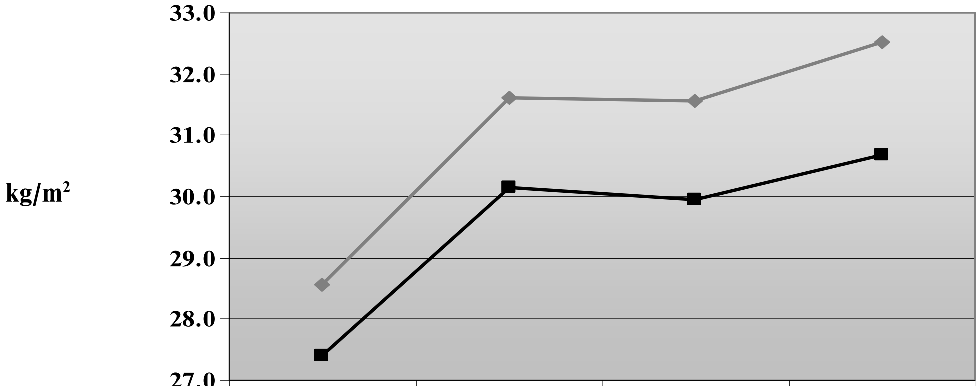


Fig. 3
Average values of BMI (kg/m²) in first (BMI I) and second measurements (BMI II)



	20 y.	30 y.	40 y.	50 y.
BMI I	28.57	31.61	31.57	32.52
BMI II	27.41	30.15	29.96	30.67

TABLE 2
The shift among categories BMI (frequency, %)

Age	Measurement I.					Measurement II.				
	BMI I	BMI II	BMI III	BMI IV	BMI V	BMI I	BMI II	BMI III	BMI IV	BMI V
20 year	15.8	52.6	21.1	10.5	0.0	21.1	63.2	5.3	10.5	0.0
30 year	10.7	35.7	28.6	17.9	7.1	17.9	39.3	17.9	17.9	7.1
40 year	2.9	25.7	54.3	14.3	2.9	8.6	45.7	34.3	8.6	2.9
50 year	0.0	28.1	50.0	18.8	3.1	0.0	50.0	34.4	15.6	0.0

Legend: I. 18.5–24.99 – normal range; II. 25.0–29.99 – overweight – pre-obese; III. 30.0–39.99 – obese of I. and II. degreses; > 40.0 – obese class III (WHO, 2004).

Mean WHR values exceeded the value of 80.0 in both measurements and in all age categories; this value suggests the risk of abdominal obesity which is associated with a higher occurrence of cardiovascular disease. Among 40 and 50 year old women, the mean WHR value exceeded the high risk limit of abdominal obesity in both measurements. More than 90% of the 30, 40 and 50 year old women ranked in the category above 80 WHR units (Fig. 4).

The average somatotypes were localized in the mesomorph-endomorphic category, markedly outside the borders of the somatogram. The only exception was the category of 20 year old women, who ranked in the mesomorphic-endomorphs category. A shift in the somatogram of the youngest women means that a statistically significant decrease occurs not only in endomorphy but also in mesomorphy, which seems to be a negative effect. The biggest shifting of the constitution was found in 20 year old women.

Endomorphy was a dominant mean somatotype at baseline measurements in all age categories. During final measurements the values of the endomorphic and mesomorphic component were equalized in 30 year old women. On Fig. 5 we can also observe shifts in the individual somatotypes (denoted by identical numbers), which seemed to be extreme (Fig. 5 and 6).

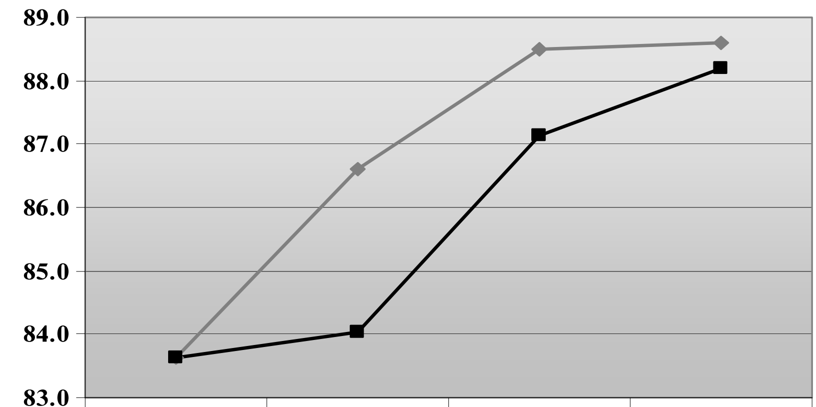
Based on the analysis of variations (ANOVA, LSD Fischer's test) it was found that significant differences are seen in the determined quantity of the percentage fat fraction in consideration of the respective methods and respective repeated measurements ($p < 0.001$). The quantity of the fat component significantly increases according to the method used in the sequence as follows: % fat Pařízková $\rightarrow$ % fat Matiegka $\rightarrow$ % fat QuadScan, and shows a significant reduction in the relative fat quantity between the two measurements (Fig. 7).

The representation of the fat component quantity in the particular BMI categories during the 1^{st} and 2^{nd} measurements shows an almost identical trend of an increased quantity of subcutaneous fat, according to the method of Matiegka and Pařízková. For the QuadScan method, the representation of the fat fraction is different, with the highest variation being in the 1^{st} and 5^{th} BMI category (Fig. 8 and 9).

The analysis of body composition according to the method of Matiegka revealed a high representation of the fat component in all age categories, which exceeds the representation of the muscle fraction, in relative values, during the first measurement. In the second measurement after the application of the therapy, we observed at least comparable muscle and fat fractions, or more precisely growth of the muscle component, in relative values, in all age categories. The effects of therapy resulted in, a reduced average subcutaneous fat quantity and a relative increase in the muscle fraction in all our groups (Fig. 10).

The quantity of fat component determined by bioelectrical impedance using the Tanita device was the highest, when compared to the other methods, and reached 40.43% in the consolidated group. The quantity of the fat fraction determined by this method showed the lowest reduction – only to 38.4% (SD = 5.02, MAX = 49.0%, MIN = 26.7%). Segmental analysis using the Tanita device showed an almost identical quantity of the fat component on the extremities, exceeding the 40% limit, with a slightly increased share of fat on the left arm. Paradoxically was recorded the lowest quantity of fat on the trunk, where the mean values reached 37.15% (TABLE 3).

Fig. 4
The changes of average values WHR in measured groups



	20 y.	30 y.	40 y.	50 y.
WHR I	83.6	86.6	88.5	88.6
WHR II	83.6	84.0	87.1	88.2

Fig. 5
Individual and average somatotypes in the observed groups

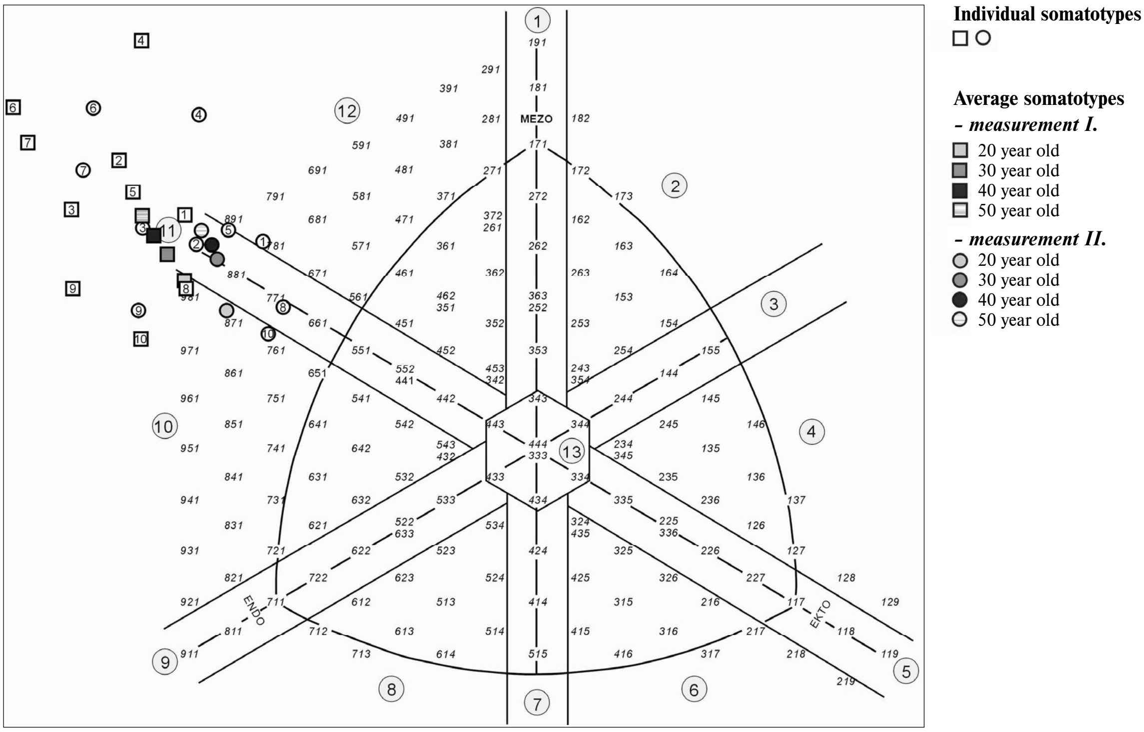


Fig. 6
The changes in average values of mesomorphy and endomorphy

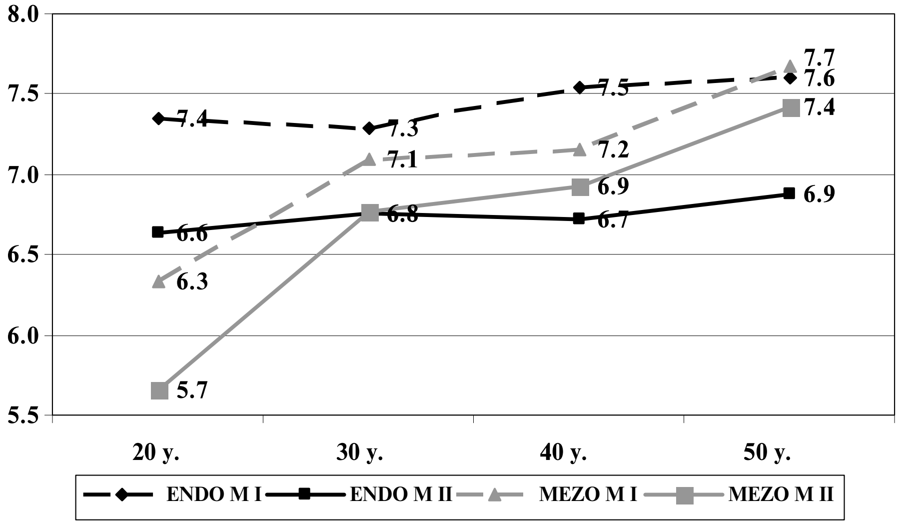


Fig. 7
Average values of percentage fat according to different methods

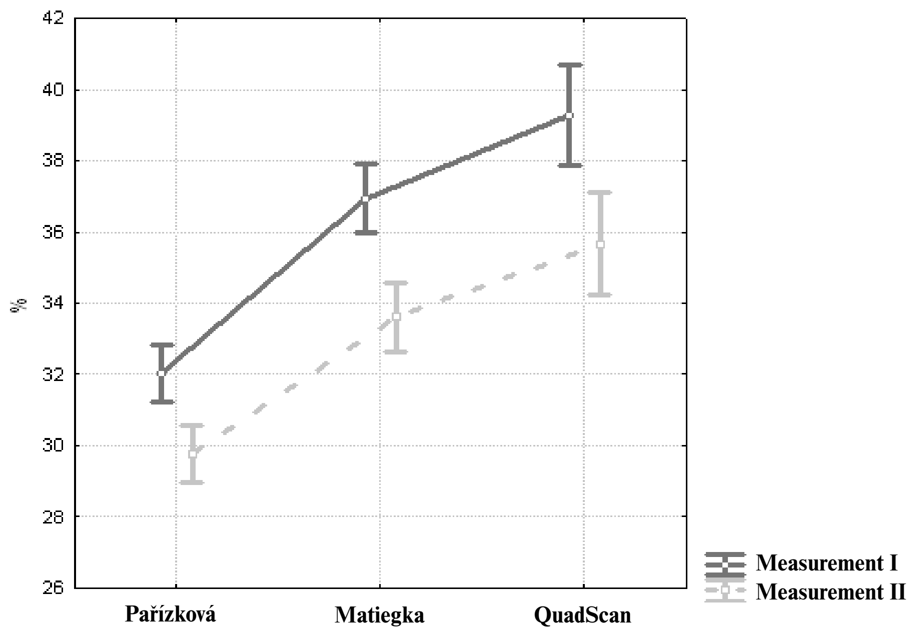


Fig. 8
Dependence of the fat fraction quantity on the BMI category during the first measurement

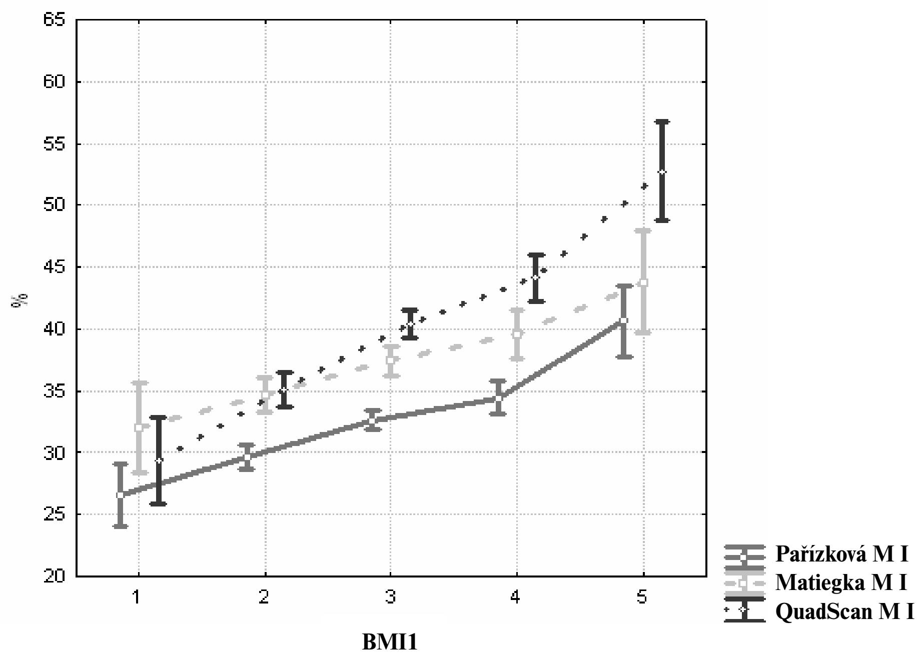


Fig. 9
Dependence of the fat fraction quantity on the BMI category during the second measurement

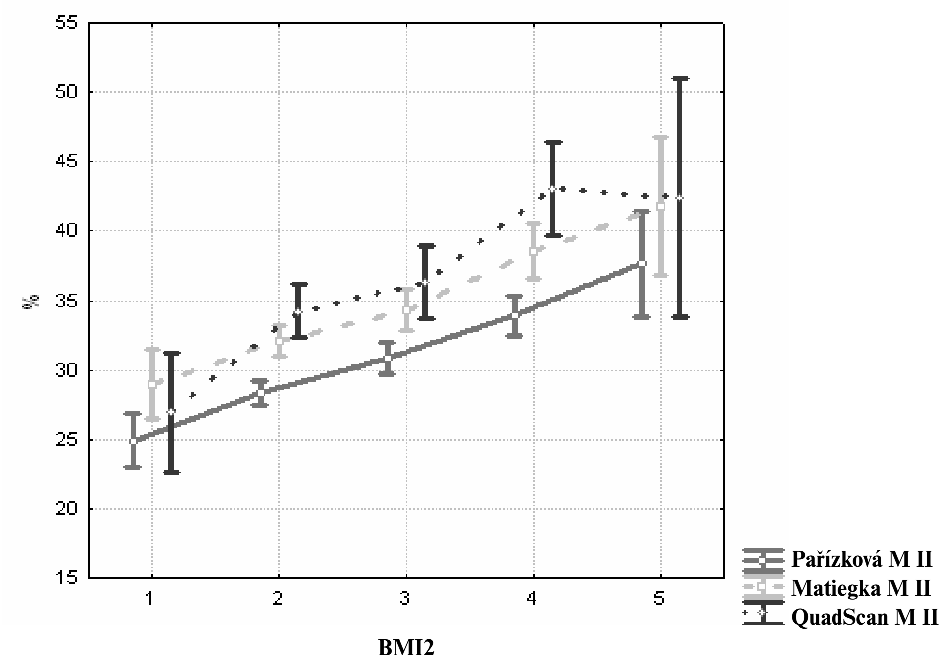


Fig. 10
Body composition according to the method of Matiegka

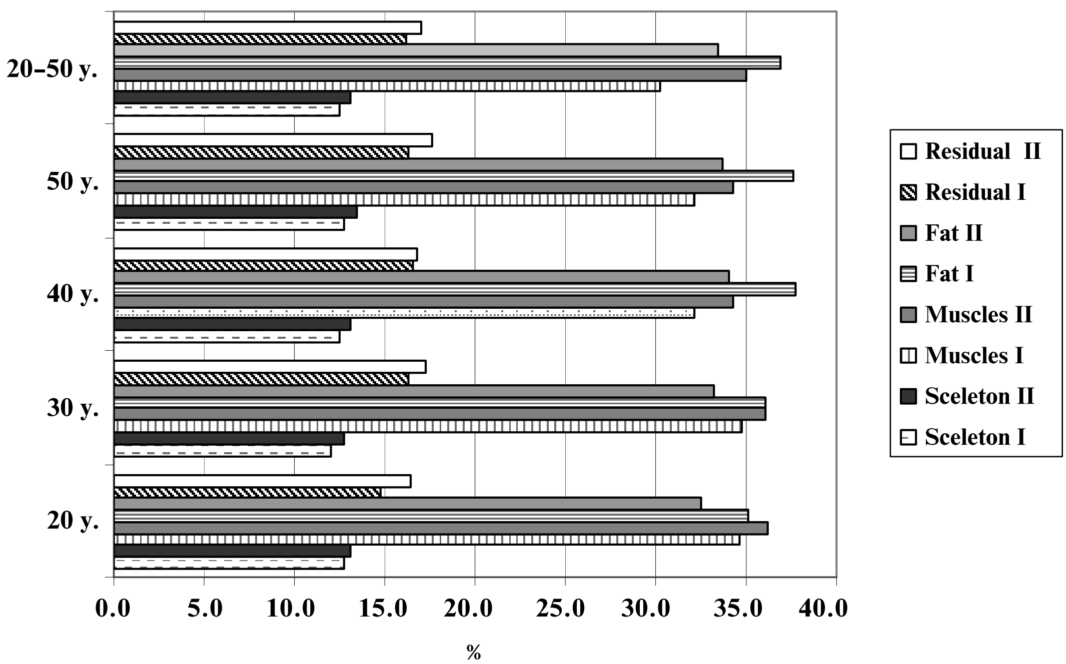


TABLE 3
The analysis of body composition on segments

SEGMENTS	RIGHT EXTREMITY				LEFT EXTREMITY			
	M	SD	X_{min}	X_{max}	M	SD	X_{min}	X_{max}
UPPER EXT.								
Fat (%)	41.56	6.42	26.70	53.60	42.43	6.43	28.90	54.80
Fat (kg)	1.90	0.63	0.80	3.50	2.05	0.72	0.90	3.90
FFM (kg)	2.55	0.29	1.90	3.40	2.65	0.32	2.00	3.60
Muscle m. (kg)	2.38	0.27	1.80	3.20	2.45	0.31	1.80	3.30
LOWER EXT.								
Fat (%)	41.74	4.22	32.10	50.40	41.79	4.17	31.70	49.90
Fat (kg)	6.40	1.49	3.70	9.70	6.31	1.46	3.70	9.50
FFM (kg)	8.76	0.96	8.00	12.00	8.61	0.92	7.00	11.40
Muscle m. (kg)	8.25	0.90	6.60	11.30	8.12	0.86	6.60	10.80
TRUNK								
Fat (%)	37.15	5.85	22.70	48.70				
Fat (kg)	17.03	4.72	7.50	29.80				
FFM (kg)	28.06	2.81	23.10	36.00				
Muscle m. (kg)	26.82	2.39	20.60	30.90				

Legend: Muscle m. (kg) – predicted muscle mass, FFM – fat free mass.

CONCLUSION

- Movement and exercise therapy in combination with changes of dietary regimes within STOB body weight reduction courses has a nearly 15 year tradition in the Czech Republic and has had significant effects on clients' somatic condition.
- We recorded changes in somatic parameters, not only for body weight but also circumference parameters, especially on the trunk, lower extremities, and significant positive changes in the fractionation of the body weight (according to all methods).
- Redistribution within the respective bodily fractions can be considered positive, as the quantity of the fat component decreases while the muscle component increases.
- The reduction of BMI and WHR is less significant, but a positive redistribution shift can also be observed in these categories.
- The segmental analysis of body weight distribution using the bioelectric impedance technique demonstrated excess fat not only on the trunk, but in particular on the lower extremities, even though a predominance of abdominal obesity can be expected in terms of circumference parameters.
- Strong willpower is an important feature and an integral part of intervention but not every woman owns it. So there is always some small percentage of women who neither lose weight nor circumferential parameters and subcutaneous fat.

ACKNOWLEDGMENT

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PŮSOBENÍ KOGNITIVNĚ-BEHAVIORÁLNÍ PSYCHOTERAPIE NA TĚLESNÉ SLOŽENÍ A KONSTITUCI

(Souhrn anglického textu)

Obezita je chronické onemocnění moderní doby, které není pouze kosmetickým problémem, ale problémem bio-sociálně-psychologickým, tzn., že obézní lidé mají kromě zdravotních problémů i problémy sociální a psychické. Vyskytují se u nich deprese, často mají sníženou sebedůvěru a problémy při uplatnění v zaměstnání. Hlavním cíle studie bylo sledování změn somatických parametrů pod vlivem působení fyzické aktivity a modifikace nutričních zvyklostí u klientek STOB kurzů (kurzy pro snižování nadváhy a obezity) u žen ve věku 20–60 let (n = 114).

Byly použity standardizované antropometrické metody pro stanovení základních somatických indexů – hmotnostně-výškových, indexů rizikovosti a indexů centrality, tělesného složení dle metody Pařízkové (1962) a Matiegky (1927) a frakcionace tělesné hmotnosti dle metody bioelektrické impedance, s ohledem na segmentální analýzu (QuadScan 4000; Tanita BC 418-MA). Ženy byly rozděleny do souborů dle decénií. Ženy byly měřeny na začátku a na konci kurzu, který trval 12 týdnů. Kurzy STOB jsou realizovány profesionálními pracovníky, kteří se věnují nejen pohybové aktivitě, ale také úpravě výživových a stravovacích stereotypů.

Ve sloučeném souboru při vstupním vyšetření dosáhl BMI průměrné hodnoty 31,34; maximální hodnota však přesáhla hranici těžké obezity 47,56. Na základě kategorizace BMI dle WHO bylo do kategorie normy zařazeno pouze 7,5 % žen, v kategorii nadváhy se vyskytovalo 33,3 % souboru a 57 % souboru bylo obézních, z toho morbidní obezity dosáhlo 5 % žen. Nejnižší hodnoty BMI se vyskytovaly u nejmladších žen (20–30letých), nejvyšší naopak v nejstarší věkové kategorii, avšak v ostatních věkových kategoriích se vzájemně signifikantně neodlišovaly. Průměrná hodnota WHR byla 87,25, z toho 85,6 % klientek přesáhlo hranici rizikovosti. Nejnižší průměrná hodnota se opět nacházela u skupiny nejmladších žen (83,6), nejvyšší (88,6) u skupiny nejstarších žen. Na

základě hodnocení množství podkožního tuku dle metodiky Matiegky 57,5 % žen disponovalo více než 30 % tuku, z toho v kategorii nad 40 % podkožního tuku se nacházelo 28,75 % souboru. Hodnoty indexů centrality (1,3–1,5), které dokumentují rozložení podkožního tuku v jednotlivých oblastech těla, korespondují s vyššími hodnotami WHR a potvrdily především uložení tuku na trupu vzhledem ke končetinám. Byl tedy potvrzen výskyt abdominálního typu obezity. Na základě segmentální analýzy realizované metodou bioelektrické impedance bylo nejvíce tuku determinováno na dolních končetinách.

Intervence prostřednictvím pohybové aktivity a změny výživových zvyklostí má především individuální dopad. Na základě hodnocení průměrných hodnot obvodových parametrů došlo ke snížení především obvodu pasu, břicha a boků, případně ke snížení obvodových parametrů na dolních končetinách (obvody gluteálního a středního stehna). Snížily se také průměrné hodnoty tělesné hmotnosti, BMI a WHR a zastoupení množství tukové složky v absolutních i relativních hodnotách. Ve všech kategoriích jsme zaznamenali signifikantní snížení endomorfie. Velmi významnou vlastností je silná vůle, která je nedílnou součástí intervence a kterou ne každá žena disponuje. Takže vždy v kurzech nacházíme i malé procento žen, které nesníží ani hmotnost, ani nedojde ke snížení obvodových parametrů a množství podkožního tuku zůstane stejné jako před nástupem na terapii.

Klíčová slova: klienti STOB kurzů, tělesné složení, typologie, BMI, nadváha, obezita různého typu.

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DETERMINATION OF THE VAGAL THRESHOLD AND CHANGES OF IT'S USING

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Exercise intensity causes changes in the activity of both branches of the autonomic nervous system (ANS) as involved in cardiovascular system regulation. Reduction in vagal activity and an increase in sympatho-adrenal activity is associated with an increase in death risk from both cardiac and arrhythmic causes during exercise. The main aim of this work was to develop a simple mathematic algorithm for determination of critical exercise intensity, at which, if exceeded, the cardiovascular system starts to be influenced dominantly by rising sympathetic activity including catecholamine and a significant withdrawal in cardiac vagal activity (vagal threshold – T_{VA}) occurs. The testing group consisted of 10 volunteers (men). Their mean age was 27.24 ± 3.23 years and the mean value of their maximal oxygen uptake (VO_2max) was 50.24 ± 4.63 $ml \cdot kg^{-1} \cdot min^{-1}$. ANS activity was monitored by the microprocessor diagnostics system VarCor PF 7 and assessed by a non invasive spectral analysis (SA) of heart rate variability (HRV) method. The power of the high frequency component (P_{HF}) was calculated by integrating the area under the power spectral density curve in the frequency range from 0.15 to 0.5 Hz. Changes in autonomic cardiac regulation were assessed during walking in the steady state with exercise intensities ranging from 20 to 70% of maximal heart rate reserve (MHRR) on the treadmill. Each exercise intensity increases of about the 10% MHRR in a range from 20 to 70% MHRR led to a significant decrease in vagal activity. A designed mathematic algorithm for detecting the deflection point of the vagal activity during incremental exercise intensity revealed T_{VA} at 43.63 ± 4.66% MHRR. We can state that the designed algorithm for detection of T_{VA} enables an estimation of such a "safe" intensity, when the vagal activity is still preserved and sympathetic activity does not markedly rise up during exercise. The estimation of T_{VA} could be recommended especially for the exercise prescription for patients with both reduction HRV, and at risk for sudden cardiac death.

Keywords: Spectral analysis of heart rate variability, exercise intensity, vagal threshold, prescription of the training exercise.

INTRODUCTION

A sedentary lifestyle or physical inactivity is generally associated with the appearance of the most relevant chronic diseases. On the other hand, regular endurance exercise represents an effective preventive and therapeutic tool (Hilberg, 2008) against such diseases. However, the patients with cardiovascular diseases who practice exercise are exposed to certain risks resulting from insufficient heart function, an increased tendency to myocardial arrhythmias and also from changes in the bloodstream (ACSM, 2007). The level of intensity seems to be a crucial risk factor of sudden cardiac death or myocardial arrhythmias; therefore, its optimizing is a basic requirement for safe exercise.

The cardiovascular system is mostly controlled by autonomic activity through the activity of the sympathetic and parasympathetic pathways of the ANS, and their activity depends mainly on the intensity of the exercise (Arai et al., 1989; Casedei et al., 1995; Parekh & Lee, 2005; Stejskal et al., 2001; Yamamoto, Hughson, & Peterson, 1991). At low intensity, tachycardia occurred mainly due to a withdrawal of efferent vagal activity (Perini et al., 1990). Rising sympathetic activity together with the level of circulating catecholamine plays a major role in heart regulation at higher intensities (Breuer et al., 1993; Kluess, Wood, & Welsch, 2000). With the dominant increase in sympatho-adrenal activity, higher demands on compression heart work are associated therewith (Ganong, 1999), and thereby, increase in the risk of both heart and circulation failure are related. From the presented data it is clear that patients with a higher risk of sudden cardiac failure should exercise only at such an intensity as does not lead to a significant increase in sympatho-adrenal activity, but which enables changes in the vagal activity regulation of the cardiovascular system.

As optimal physical activity for healthy people is endurance activity with an intensity set between 60–70% of VO_2max being recommended (ACSM, 1990). In people with some health limitations, lower intensity exercise is recommended, e. g. hypertension patients should keep their exercise intensity within a range from 45 to 60 % of VO_2max (Cléroux, Feldman, & Petrela, 1999; Izdebska et al., 2004). So far, published studies have brought us different results describing exercise intensity, from which the efferent cardiac vagal modulation disappears, and the activity of the heart will be mainly mediated by the sympatho-adrenal system. For example, Perini et al. (1990) and Orizio et al. (1989) presented an intensity of about 30 and 33% VO_2max. Hautala et al. (2003) described 40% VO_2max as the dividing intensity in vagal and sympathetic cardiac modulation. According to the studies of Achten and Jeukendrup (2003) and Nakamura, Yamamoto and Muraoka (1993), the target intensity is found at 50–60% VO_2max.

Heart rate variability (HRV) is generally accepted as a feedback marker of cardiac vagal and sympathetic activity (Akselrod et al., 1981; Task Force, 1996). Due to obesity, diabetes mellitus, hypertension or several cardiovascular diseases, there is significantly decreased HRV (Kuch et al., 2004; Matsunaga et al., 2004; Nolan et al., 1998; Shibata et al., 2002) which has been associated with higher risk of sudden death or myocardial arrhythmias (Schwarz, La Rovere, & Vanoli, 1992). On the contrary, regular endurance exercise leads to an increase in vagal cardiac activity and a decrease in sympathetic activity (increase in HRV) in healthy people as well as in patients who exercised during their rehabilitation process (Cornelissen & Fagard, 2005; Dixon, Kamath, McKartney, & Fallen, 1992; Fujimoto et al., 1999; Goldsmith, Bigger Jr., Steinman, & Fleiss, 1992; Mueller, 2007; Takeyama et al., 2000).

The spectral analysis (SA) of HRV is a non invasive method for the direct assessment of vagal cardiac activity and for the indirect evaluation of sympathovagal balance. It is known that exercise intensity decreases the vagal parameters of SA HRV (Stejskal et al., 2001). Therefore, the aim of this study was to identify the critical exercise intensity level which is linked with a very mild reduction of vagal cardiac modulation (vagal threshold – T_{VA}). A sophisticated determination of T_{VA} may allow us to prescribe "safe" exercise for patients with a higher risk of sudden cardiac death or myocardial arrhythmias.

METHODS

The testing group consisted of 10 men who were studying or working at the Faculty of Physical Culture (FPC), Palacký University in Olomouc. Each testing protocol and situation was clearly and precisely described to them. The study protocol was approved by the ethics committee of the Faculty of Physical Culture, and the subjects gave written informed consent. During this study, all measurements were performed in the laboratories belonging to the Department of Functional Anthropology and Physiology of FPC PU. The investigated persons were instructed to keep an optimal regime, and vigorous physical activity was forbidden minimally for 48 hours before the testing. Further, the volunteers were not allowed to eat and drink coffee, tea, nor any substance, which could influence ANS activity, 2 hours prior to the measurement of ANS activity. All subjects were non smokers, and they were asked to come on an empty stomach for all measurements.

Before the testing, the volunteers had been investigated to preclude any medical or health limitations to perform the maximal exertion test. Usually in the morning, each tested person underwent an initial tests battery, which was performed 14 days before the start of the study in the exercise laboratory. Subjects underwent basic anthropometric measurements (height [cm], weight [kg]) and body composition was assessed using the bioimpedance method (In Body 720, South Korea). The measurement of HRV and oxygen consumption followed anthropometric measurements. The maximal running test was performed on a Lode Valliant treadmill (Netherlands). The test started with a warm up phase: 4 minutes (min.) at 8 $km \cdot h^{-1}$ and 10 $km \cdot h^{-1}$, respectively. Immediately after the warm up, the inclination of the treadmill increased from 0 to 5%, and speed remained at 10 $km \cdot h^{-1}$. Then the speed increased every minute by 1 $km \cdot h^{-1}$ till exhaustion. During the test, the subject breathed in a mask: ventilation and both O_2 and CO_2 exchange were analyzed by a gas ventilator ZAN 600 Ergo USB (Germany).

ECG data were collected during a standardized ortho-clinostatics maneuver of lying–standing–lying by the VarCor PF 7 system (Salinger & Gwozdziewicz, 2008), which requires for HRV analysis 256 artifacts free of subsequent R–R intervals for each position. Frequency domain analyses were performed according to the methods described by Salinger et al. (1998). The amplitude density of the collected signal was estimated using the fast Fourier Transform method with a partly modified Coarse-Graining Spectral Analysis algorithm (Yamamoto & Hughson, 1991). The power of the mean spectral component with high frequency (P_{HF}) was calculated by integrating the area under the power spectral density curve in the frequency ranges according to Salinger et al. (1998) with a result of: P_{HF} from 0.15 to 0.5 Hz.

Changes in autonomic cardiac regulation were assessed during walking in the steady state with exercise intensities ranging from 20 to 70% of MHRR on the treadmill. The value of the MHRR was calculated for each subject individually as a differential of the HRmax value, obtained within the framework of the maximal exertion test, and the HR rest value estimated as a mean HR in the third position (lying) during the investigation of HRV. The target HR was expressed as the HR value (HR_T = MHRR · [% exercise intensity / 100] + HR rest) within the range of ± 5 $beat \cdot min^{-1}$. The measurement of both HRV and oxygen consumption lasted 5 minutes. The measurement itself followed a 5 minute warm up aimed at the achievement of HR_T. The investigations at 50, 60 and 70% MHRR coursed separately in different days. Only intensities of 20–30–40% MHRR were done by the subject all together during one measurement. The intensities were chosen randomly.

An algorithm of T_{VA} calculation based on load curve is described in this article. The result of a load curve measurement is the set of parameters $\{x_i, y_i\}$, $i = 1, 2, ...n$, where y_i is the value of P_{HF} [ms^2] measured within load x_i [%]. In our ramp test schedule, the load is increased step by step at levels of 20%, 30%,...70%, and so on, in our case bringing a result of $n = 6$. The mathematics algorithm does not include resting P_{HF}.

The algorithm splits the measured set of parameters into two subsets, calculates a regression line in each subset and calculates the T_{VA} as a point of intersection of two regression lines. The first subset contains the parameters $\{x_i, y_i\}$, $i = 1, 2, ...k$ and the second subset contains the parameters $\{x_i, y_i\}$, $i = k, k+1, ...n$. The parameters with index k belong to both subsets.

The regression line

$$y = a_1 + b_1 x \quad (1)$$

with coefficients

$$b_1 = \frac{k\sum_{i=1}^{k} x_i y_i - \sum_{i=1}^{k} x_i \sum_{i=1}^{k} y_i}{k\sum_{i=1}^{k} x_i^2 - \sum_{i=1}^{k} x_i \sum_{i=1}^{k} x_i}, \quad a_1 = \frac{1}{k}\sum_{i=1}^{k} y_i - \frac{b_1}{k}\sum_{i=1}^{k} x_i \quad (2)$$

is calculated from values in the first subset. The regression line

$$y = a_2 + b_2 x \quad (3)$$

with coefficients

$$b_2 = \frac{(n-k+1)\sum_{i=k}^{n} x_i y_i - \sum_{i=k}^{n} x_i \sum_{i=k}^{n} y_i}{(n-k+1)\sum_{i=k}^{n} x_i^2 - \sum_{i=k}^{n} x_i \sum_{i=k}^{n} x_i},$$

$$a_2 = \frac{1}{(n-k+1)}\sum_{i=k}^{n} y_i - \frac{b_2}{(n-k+1)}\sum_{i=k}^{n} x_i \quad (4)$$

is calculated from values in the second subset. The T_{VA} is calculated as the point of intersection $[x_P, y_P]$ of lines (1) and (3), the resulting equations are

$$x_P = \frac{a_1 - a_2}{b_2 - b_1}, \quad y_P = a_1 + b_1 x_P = a_2 + b_2 x_P. \quad (5)$$

The algorithm calculates the value of index k, which splits the measured set into two subsets, by means of an iterative procedure. At the beginning of this iterative procedure, the index k is set for a starting value, i. e. $k = 2$, and the condition

$$b_2 < 0 \wedge a_2 + b_2 x_n > 0 \quad (6)$$

is tested. If the condition (6) is fulfilled, the iterative procedure is stopped and the value of index k is taken. If the condition (6) is not fulfilled, the index k is incremented, i. e. $k = k+1$, the coefficients (4) are calculated again and the condition (6) is tested. The iterative procedure continues until the condition (6) is fulfilled. The meaning of this condition is that the regression line (3) has a decreasing slope and lies above zero level within the interval $\langle x_k, x_n \rangle$. It can be said that the goal of the iterative procedure is to find such a regression line (3) which does not cross the x axis.

All statistical processes were performed in MS Excel 2003, Statistica 6.0 software and the algorithm for detection of the T_{VA} was created in MatLab 7.5.

RESULTS

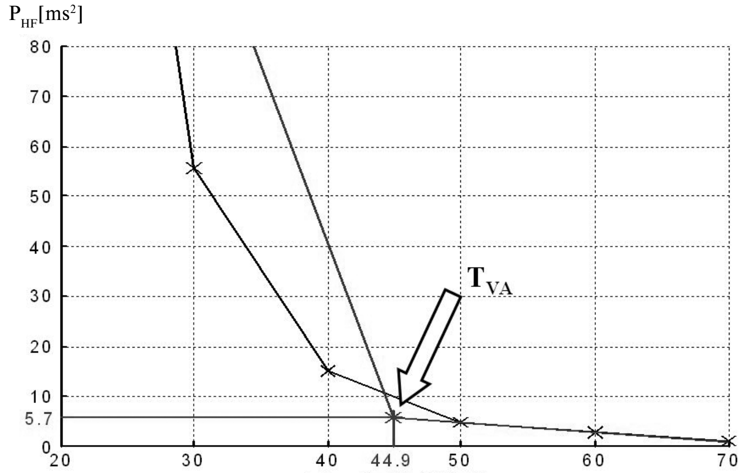
The Wilcoxon test revealed significant differences in P_{HF} values between all assessed exercise intensities. Fig. 2 clearly shows that the highest reduction in P_{HF} values occurred up to 40% MHRR. On the contrary, minimal attenuation of P_{HF} values was detected at over 50% MHRR.

TABLE 1
Basic characteristics of the testing group

Age [year]	**BMI** [kg·m^{-2}]	**Body Fat** [%]	**HRrest** [beat·min^{-1}]	**HRmax** [beat·min^{-1}]	**ANT_R** [beat·min^{-1}]	**VO_2max** [ml·kg^{-1}·min^{-1}]
27.24 ± 3.23	24.89 ± 1.81	9.39 ± 3.97	50.30 ± 2.21	193.0 ± 9.32	170.0 ± 8.82	50.24 ± 4.63

Legend: VO_2max – maximal oxygen uptake, HRrest – resting heart rate, HRmax – maximal heart rate, ANT_R – respiratory anaerobic threshold, BMI – Body Mass Index.

Fig. 1
Illustrated example of the vagal threshold assessment



Legend: % MHRR – percent of the maximal heart rate reserve, P_{HF} – high frequency power, T_{VA} – vagal threshold.

TABLE 2
Statistical differences of the P_{HF} values during different exercise intensity

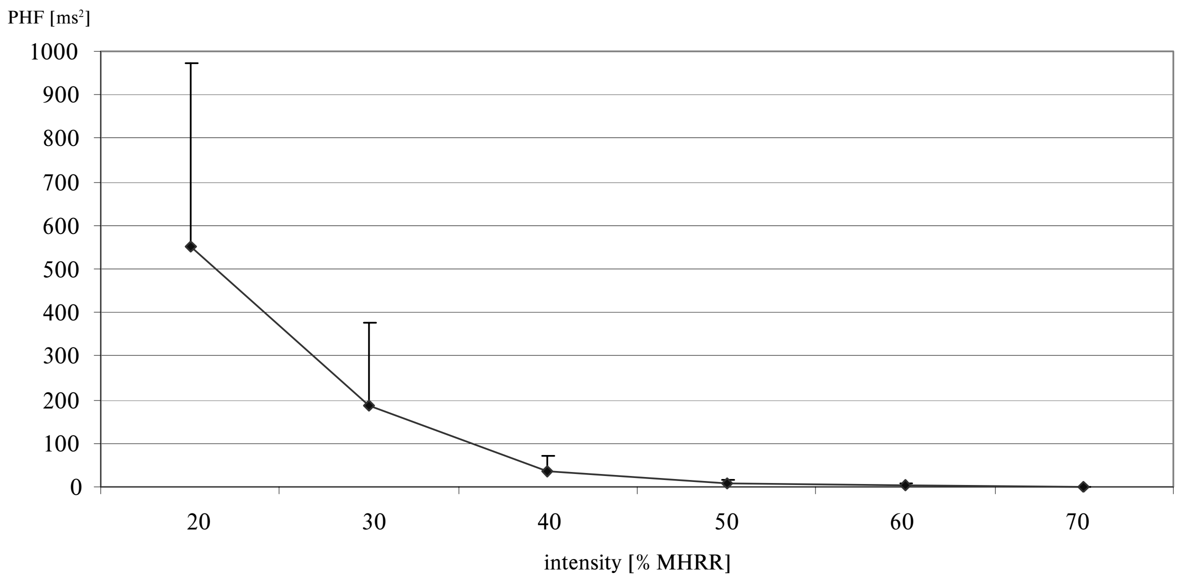
Parameter [units]	R	20% MHRR	30% MHRR	40% MHRR	50% MHRR	60% MHRR	70% MHRR
HR [beat·min⁻¹]							
M	83.23	78.02	91.05	106.42	122.03	136.86	151.08
SD	5.90	4.13	2.75	3.67	4.42	6.51	6.80
P_{HF} [ms²]							
M	288.94	551.62	185.80	37.24	9.05	4.25	0.86
SD	402.36	421.37	189.63	34.18	5.06	2.54	0.52
P_{HF} [ms²] *p*	R vs 20* R vs 30* R vs 40** R vs 50** R vs 60** R vs 70**	20 vs 30** 20 vs 40** 20 vs 50** 20 vs 60** 20 vs 70**	30 vs 40** 30 vs 50** 30 vs 60** 30 vs 70**	40 vs 50** 40 vs 60** 40 vs 70**	50 vs 60* 50 vs 70**	60 vs 70**	

Legend: R – rest HR during standing position, P_{HF} – high frequency power, M – mean value, SD – standard deviation, % MHRR – percent of the maximal heart rate reserve, HR – heart rate, p – significant values (Wilcoxon test), *$p \leq 0.05$, **$p \leq 0.01$, vs – versus.

DISCUSSION

Cardiovascular adjustment in exercise represents a combination and integration of the following factors: central command, autonomic cardiac regulation, reflexes originating in the baroreflex, and circulating catecholamine (Aubert, Seps, & Beckers, 2003). Mechanisms of cardiac regulation apply their influence to increasing cardiac output during exercise, when demands of working muscles for oxygen and energy substrates delivery increase (Åstrand, Rodahl, Dahl, & Strømme, 2003). The increase in cardiac output is caused by heart rate acceleration and an increase in stroke volume during exercise. It is well accepted that decrease in efferent cardiac vagal activity allows an increase in cardiac output during low exercise intensity (Arai et al., 1989; Perini et al., 1990; Tulppo et al., 1998). In addition, the regulation effects of both the sympathetic activity and catecholamine are negligible for the heart activity at this moment. At low intensity, in humans, an increased sympathetic activity together with norepinephrine is responsible throughout the stimulation of α receptors for redistribution of blood flow away from the splanchnic area, the kidney, and resting skeletal muscles to the working muscles (Christensen & Galbo, 1983). At higher intensities, the vagal withdrawal came to be insufficient for further augmentation of the cardiac output, and thereafter, increments in cardiac output are attributed with the positive inotropic

Fig. 2
Dynamics of spectral measure P_{HF} within different exercise intensity



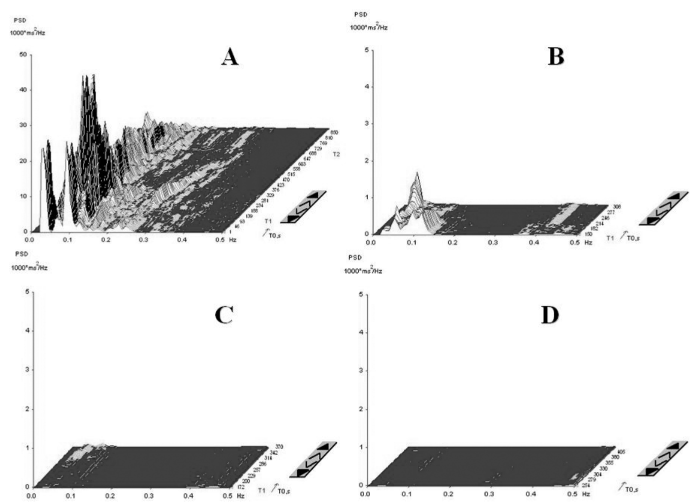
Legend: % MHRR – percent of the maximal heart rate reserve, P_{HF} – high frequency power.

TABLE 3
Level of the vagal threshold expressed by various parameters

Parameters	*M*	*SD*	*Max*	*Min*
INT [% MHRR]	43.63	4.66	49.73	37.10
HR [beat·min^{-1}]	112.06	9.30	132.97	100.18
P_{HF} [ms^2]	10.87	5.87	19.53	1.80

Legend: INT – exercise intensity, P_{HF} – high frequency power, % MHRR – percent of the maximal heart rate reserve, HR – heart rate, M – mean value, SD – standard deviation, Max – maximal value, Min – minimal value.

Fig. 3
3D Graphs of the SA HRV during different intensity



Legend: A – 20, 30, 40%, B – 50%, C – 60%, D – 70% maximal heart rate reserve.

and chronotropic effects of increases in sympatho-adrenal activity (Breuer et al., 1993; Ganong, 1999; Kluess, Wood, & Welsch, 2000).

The conclusions associated with investigation of autonomic cardiac behavioral during exercise have used rather misleading data. In a relatively older study, Robinson, Epstein, Beiser and Braunwald (1966) described that an initial rise in HR connected with vagal withdrawal can reach a maximum increase of 30 beats·min^{-1}. This further HR increment has been ascribed to increased cardiac sympathetic activity. On the basis of the dynamics of the relative value of the very low frequency power during exercise, Perini et al. (1990) states that 30% VO_2max represents a threshold in cardiovascular adjustment when increases in the sympathetic activity during exercise occur. It is interesting to note the study by Hautala et al. (2003), who used the fractal method of HRV during exercise for analysis of R–R intervals, and investigated that sympathetic activity starts to dominate after vagal activity in the cardiac regulation at an intensity of 40% VO_2max. According to Tulppo et al. (1998), the vagal modulation disappears at the level of 50–60% VO_2max, whereafter the increase in heart activity is mainly mediated by sympathetic activity.

Cottin, Papelier and Escourrou (1999) and Warren Jaffe, Wraa and Stebbins (1997) together concluded that HRV is a valid technique for the non invasive assessment of vagal activity during exercise, but its validity as measure of sympathetic activity during exercise is equivocal. Therefore, P_{HF} as a good index of vagal activity (Task Force, 1996) was measured during walking in a steady state at that intensity level, which ranges from 20 to 70% MHRR in this study. Our results showed that each enhancement in the intensity by about 10% MHRR evoked a significant reduction in vagal activity. This study confirmed the previously published statement about a negative relationship between intensity and HRV (Arai et al., 1989; Parekh & Lee, 2005; Stejskal et al., 2001; Yamamoto, Hughson, & Peterson, 1991).

The dynamics of the P_{HF} clearly shows that the most pronounced attenuation in vagal activity during exercise occurred between 20–50% MHRR. Otherwise, the higher intensity led to another significant withdrawal in vagal activity, but these changes were not so obvious compared to changes in vagal activity observed at low intensity. According to our opinion, such a residual vagal activity at above 50% MHRR has neither marginal nor any regulatory effect on the heart action.

Several chronic diseases cause significant withdrawal in vagal cardiac regulation. It has been also revealed that such a decline in vagal activity has been associated with the electrical instability of the myocardium, malignant arrhythmias or ventricular fibrillations (Nolan et al., 1998; Schwarz, La Rovere, & Vanoli, 1992; Vanoli & Schwarz, 1990). Therefore, exercise below T_{VA} may have a protective effect against the mentioned medical complications due to persisting vagal activity. On the other hand, exercise intensity over T_{VA} level induces a marked enhancement in sympato-adrenal system activity, which causes not only a rising risk of myocardial arrhythmia development, but also increases demands on the compression of the heart's work, which may lead to its failure in threatened patients.

In 2002, Shibata et al. came up with the idea of a new method to determine exercise intensity for obese women based on cardiac vagal activity. They suggested that exercise at the T_{VA} level represents a safe exercise intensity in the light of cardiac stress. Hence, T_{VA} may be recommended generally for people who might possess a lower cardiac sympatho-vagal balance. They have established the T_{VA} level at HR 114.6 ± 8.5 beats·min^{-1}. The HR value of our T_{VA} was almost equal to the HR value of T_{VA} of the last cited study. However, our tested subjects were about 13 years younger than volunteers in the study of Shibata et al. (2002), and therefore the relative load level in our case (with a mean value of T_{VA} 45% MHRR) was lower than in their study. From this point of view, we state that it is better to express exercise intensity in relative values (% VO_2max or % MHRR) than in absolute value of HR.

The relative small age dispersion (27.24 ± 3.23 years) can be considered as a limit to the applicability of this study because of the fact that an incremental increase in age causes a reduction in HRV, mainly due to a decrease in vagal activity (Finley & Nugent, 1995; Fukusaki, Kawakubo, & Yamamoto, 2000; Šlachta et al., 2002; Vallejo et al., 2004). It will be in the future very interesting to examine the relationship between T_{VA} level and age. Tulppo et al. (1998) have already published that exercise intensity at which instantaneous R–R interval variability disappeared and was not related to age.

CONCLUSIONS

In conclusion we can state that the monitoring of HRV by the SA HRV method enables us to assess changes in vagal cardiac regulation during walking in a steady state. In addition, each enhancement of the intensity by about 10% MHRR in a range from 20 to 70% MHRR evoked a significant decrease in vagal activity. Exercise intensity at around 45% MHRR may represent the mean level of T_{VA} in our measured subjects. The extension number of other age matched groups is a necessary condition for further application of T_{VA} within the prescription of a safe exercise level for patients with a reduction in ANS activity and an increased risk of cardiac complications.

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STANOVENÍ VAGOVÉHO PRAHU A MOŽNOSTI JEHO VYUŽITÍ

(Souhrn anglického textu)

Cílem této studie bylo navrhnout jednoduchý matematický postup, podle kterého by bylo možno stanovit takovou hraniční intenzitu zatížení, nad kterou se redukovaná vagová aktivita dále výrazně nemění a kardiovaskulární systém je dominantně řízen zvyšující se aktivitou sympatoadrenálního systému (vagový práh – T_{VA}). Testovaný soubor tvořilo 10 mužů ve věku 27,24 ± 3,23 let s hodnotou maximální spotřeby kyslíku 50,24 ± 4,63 ml.kg^{-1}.min^{-1}. Aktivita ANS byla hodnocena pomocí neinvazivní metody spektrální analýzy (SA) variability srdeční frekvence (HRV). Změny v autonomní kardiální regulaci byly posuzovány během chůze na běhátku v setrvalém stavu při intenzitách zatížení od 20 % do 70 % maximální tepové rezervy (MTR). Zvýšení intenzity zatížení o 10 % MTR v rozmezí od 20 % do 70 % MTR vedlo vždy k signifikantnímu snížení aktivity vagu. Navržený postup pro stanovení deflekčního bodu křivky závislosti P_{HF} na intenzitě zatížení, za kterým již P_{HF} výrazně neklesá, umožnil identifikovat T_{VA} na úrovni 43,63 ± 4,66 % MTR. Navržený algoritmus stanovení T_{VA} dovoluje odhadnout při tělesné práci „bezpečnou“ intenzitu zatížení, při které je ještě zachována aktivita vagu a aktivita sympatiku se ještě výrazně nezvyšuje. Stanovení T_{VA} se může uplatnit zejména při preskripci intenzity zatížení v rámci programu pohybové aktivity u pacientů s redukovanou aktivitou ANS a se zvýšeným rizikem náhlé srdeční příhody.

Klíčová slova: spektrální analýza variability srdeční frekvence, intenzita zatížení, vagový práh, preskripce programu pohybové aktivity.

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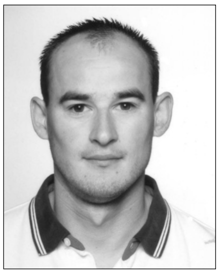

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First-line publications

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CHANGES IN HEART RATE VARIABILITY AFTER A SIX MONTH LONG AEROBIC DANCE OR STEP-DANCE PROGRAMME IN WOMEN 40–65 YEARS OLD: THE INFLUENCE OF DIFFERENT DEGREES OF ADHERENCE, INTENSITY AND INITIAL LEVELS

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The aim of the present study was to investigate how changes in heart rate variability (HRV) after a 6 month long aerobic dance or step-dance programme are related to adherence, to exercise intensity and to the initial level of HRV. The experimental group consisted of 44 women aged 47.3 ± 5.4 years. Methods used were the spectral analysis of short term recordings of R–R intervals and the incremental uphill walk jog test till maximum on the treadmill. Intervention consisted of a group aerobic exercise, done for a period of six months, three times per week, for 40–45 minutes. Exercise intensity was monitored and followed using monitors of heart rate.

There were great differences among the women in the realised training units (9–73). The average weight decrease which occurred measured from 72.1 ± 12.9 kg to 71.1 ± 11.8 kg and the average VO_2max increase measured from 33.3 ± 5.7 ml.kg^{-1}.min^{-1} to 37.0 ± 5.1 ml.kg^{-1}.min^{-1}. The exercise programme did not cause any statistically significant changes in the monitored parameters of HRV. Only two characteristics of exercise intervention (total duration of the aerobic part of the exercise and the average intensity of the exercise) correlated with changes in HRV. A negative correlation was found between most monitored parameters of HRV and their changes. Correlation analyses suggested that the shift of spectral power from sympathetic to parasympathetic happened in the women with a higher adherence to the programme, but it was shown that the influence of volume and quality of exercise were suppressed by the initial level of each parameter of HRV. The lower or worse the initial values of these parameters were before starting the programme, the greater were their increases in a half a year. With regards to the relationship between aerobic power and ANS activity, it is possible to state that in light of its impact on ANS activity, aerobic dance or step-dance could serve as a suitable exercise activity more for subjects with lower aerobic power.

Keywords: Heart rate variability, adherence, initial values, aerobic dance and step-dance.

INTRODUCTION

A regular physical activity leads to considerable changes demonstrated in the increase of health related fitness and in the decrease of the risk factors developing a number of disabling medical conditions which occur in people who are inactive (Physical Activity Guidelines Advisory Committee, 2008). We can postulate that for the lifelong lasting realization of a regular physical activity, the right choice of its kind is important. One of the most desired and desirable physical activities for women is aerobic dance, which can have a positive influence on aerobic power similarly to walking or jogging (Garber, McKinney, & Carleton, 1992). Aerobic dance can have a similar effect to running, especially if the intensity of the exercise, frequency and duration is the same (Milburn & Butts, 1983).

Our intention was to identify comprehensively every aspect connected to the six month long regular exercise programme of aerobic dance and step-dance. Namely these are changes in aerobic power (already published in a work by Stejskal et al., 2007), in body composition, in psychological and social factors which predetermine adherence and, last but not least, in the changes in the autonomic control of heart rate.

With advancing age, there is a decrease in activity of the autonomic nervous system (ANS) which is associated with the decrease in the activity of the parasympathetic branch which is linked to an increased risk of cardiovascular mortality (Molgaard, Sorensen, & Bjerregaard, 1991; Task Force, 1996). These changes are manifested in a decrease in heart rate variability (HRV) which is an established non invasive tool for the evaluation of the autonomic modulation of the sinoatrial node (Akselrod et al., 1981; Task Force, 1996). On the contrary, regular physical activity can have the opposite effect, which means a shift towards more parasympathetic influence and thereby an increase in HRV

(Aubert, Beckers, & Ramaekers, 2001; Carter, Banister, & Blaber, 2003; Lee, Wood, & Welsch, 2003).

The aim of the study was to investigate changes in HRV after a six month long regular (3 times per week) realization of an aerobic dance and step-dance programme among middle aged and older women (ranging from 40 to 65 years). The next aim was to assess whether potential changes in HRV are related to exercise intervention adherence, to exercise intensity and to the initial level of HRV.

METHODS

Subjects

A group of 44 women aged between 40–65 years old (47.30 ± 5.42 years) volunteered to participate in the study. Entrance criteria were an interest in exercise, a sedentary lifestyle, age from 40 to 65 years, the health state enabling participation in the exercise programme as much and as often as possible, and the willingness to undergo initial and final laboratory testing. Each subject signed an informed consent form before entering the study.

As a reaction to leaflet promotion, 75 women responded, 53 of whom underwent an entrance investigation. The medical check up excluded 4 of them; therefore the programme started with 49 and ended with 47 women. It was not possible to calculate HRV from the ECG record in three women before or after the realization of the intervention programme (there was a relatively high incidence of arrhythmia).

Laboratory tests

The investigations were carried out under relatively standard conditions (temperature 19–21 °C, humidity 40–50%) in the laboratory of the Faculty of Physical Culture at Palacký University in Olomouc, the Czech Republic. The women were asked to come with an empty stomach and to abstain from drinking coffee, alcohol and hard physical activities for 24 hours before entering the laboratory. First of all their weight and the height were measured and their body mass index (BMI) was calculated. All the tests were realised in one session one or two weeks before the start of the programme (pre-test) and than one or two weeks after the cessation of the programme (post-test).

Examination of the activity of the autonomic nervous system by means of the spectral analysis of heart rate variability

During a standardized ortho-clinostatic maneuver (supine–standing–supine) there was a short term ECG record (300 heart beats and 5 min.), which was collected for each position by means of the microcomputer diagnostics system Varia Cardio TF 4 (Salinger & Gwozdziewicz, 2008; Salinger et al., 1998). The subjects closed their eyes and were listening to relaxation music from headphones during the whole test. Only the ECG record from the third (second supine) position was analysed. Frequency domain analyses of consequent R–R intervals were performed according to the methods described by Salinger et al. (1998). The amplitude density of the collected signal was estimated using the fast Fourier transformation method with a partly modified coarse-graining spectral analyses algorithm (Yamamoto & Hughson, 1991). Transformation of the time data results ranged across a total power spectrum from 0.02 to 0.50 Hz (T_P) which was divided into power of high frequency (P_{HF}) (0.15–0.50 Hz), power of low frequency (P_{LF}) (0.05–0.15 Hz) and power of very low frequency (P_{VLF}) (0.02–0.05 Hz) (Salinger & Gwozdziewicz, 2008). Further analysed parameters were the rations of particular spectral powers (VLF/HF, LF/HF, VLF/LF), the percentage of particular spectral powers from T_P (% VLF, % LF, % HF), the mean duration of R–R intervals [ms] and MSSD (mean squared successive differences) [ms^2].

The incremental uphill walk jog test was carried out on the treadmill (Technogym runrace HC 1200, Italy) with the use of the Bruce protocol (Maud & Foster, 1995) based on the increment of each load in three minute long intervals to the point of exhaustion. The speeds and elevation of the intervals were: 1) 2.7 $km.h^{-1}$ and 10%, 2) 4.0 $km.h^{-1}$ and 12%, 3) 5.5 $km.h^{-1}$ and 14%, 4) 6.8 $km.h^{-1}$ a 16%. Oxygen consumption (as well as the other not mentioned ventilation parameters) was measured using a gas analyser (Jaeger Oxycon Delta, Germany) and heart rate with a telemetric monitor (Polar Electro S810i, Finland).

Aerobic classes

The intervention programme lasted for 6 months from September 2005 to March 2006 and was carried out as a group aerobic exercise with music under the supervision of an expert instructor. The participants of the study were randomly divided into two groups, the first group (n = 23) for aerobic dance and the second group (n = 21) for step-dance aerobic. The exercise intervention was not limited with any nutrition restriction or modification.

Aerobic dance is based on walking and step variations, knee bends, lunges (low impact aerobics – LIA), running, skipping and hopping (high impact – HIA) and their combination (low-high impact); this exercise is accompanied by the controlled movement of the arms. Step-dance aerobics is based on stepping up and stepping down with the use of two steps (10 and 13 cm), combined with step variations on the steps and apart from them as well. Every movement was planned and put together in order to create a composition (choreography) which was modified after a month. The choreographies followed didactical methods and learning techniques which are called learning patterns (Brockie, 2006).

There were three training units for both groups each week. It was possible to perform a maximum of 76 training units in a half a year. Each training unit lasted for 60 minutes and consisted of a) an initial part (warming up and stretching), b) the main (aerobic) part, c) powerening d) the final part (cooling down, stretching). The initial and main part lasted for 40–45 minutes, powerening and final part took 15 minutes.

The intensity of the exercise was monitored using a heart rate monitor (Polar A3, Finland). Each woman switched on the monitor at the beginning of the aerobic part and switched it off at the end. Exercise intensity was set up in the range (10 beats.min^{-1}) when the high limit corresponded to the anaerobic threshold evaluated by means of the V-slope method; if there were difficulties in using the above-mentioned method, the optimal heart rate (HRopt) within the range of ± 5 beats.min^{-1} was calculated according to the modified Karvonen formula (Karvonen, Kentala, & Mustala, 1957): HRopt = {[(VO_2max/350) + 0.6]. (HRmax – HRrest)} + HRrest, in which VO_2max meant maximum oxygen consumption (ml.kg^{-1}.min^{-1}), HRmax – maximum HR, and TFrest – resting HR.

Exercise intensity was also influenced by the pace of the music (beats.min^{-1}) which was different within each part of the training unit as well as according to the kind of aerobics (LIA 130–145 beats.min^{-1}, HIA 150–160 beats.min^{-1}, step-dance aerobics 125–135 beats.min^{-1}). During the first month of the intervention programme, the pace of music was slower (the average was 126–130 beats.min^{-1}) then it was gradually increased (in the last month, the average was 135–142 beats.min^{-1}).

The duration of the aerobic part of the training unit, the duration of exercise in the optimal range of HR and average exercise intensity were transferred from heart rate monitors into individual record sheets. These parameters together with the number or realised training units represented adherence to an exercise programme (TABLE 1).

Statistical analysis

The software Statistica 6.0 was used for data analysis. Baseline characteristics of the study group are presented as a means of ± standard deviations and ranges. The paired t-test was used to compare the values before and after the exercise intervention. A change of each parameter is expressed as a difference (after–before). Pearson's correlation coefficient (r_p) was calculated to determine the correlation between the change of each HRV parameter and the qualitative and the quantitative parameters of exercise intervention; this was also used to estimate the dependence of the change of each HRV parameter on its initial value. In all analyses the differences were considered significant at $p \leq 0.05$, 0.01 and 0.001.

RESULTS

From TABLE 1 it is clear that big differences among the women were in both the number of training units they participated in (9–73 from a maximum of 76) and in the total duration of every aerobic part of those training units (383–3178 min.). A high degree of variability was also seen in the duration of each exercise within the optimal range of HR (130–2449 min.) and within the exercise intensity range (49–90% MHRR) as well. On the contrary, the duration times of the aerobic or main parts of the exercise (40–44 min.) were relatively homogenous.

The style of aerobics (dance and step-dance) did not influence any of the monitored parameters significantly.

This exercise intervention caused a statistically but not logically significant reduction of weight from an average of 72.1 to 71.1 kg. Aerobic fitness expressed as VO_2max significantly increased from the average of 33.3 to 37.0 ml.kg^{-1}.min^{-1} (TABLE 2).

TABLE 3 shows that the exercise intervention used did not cause any statistically significant changes to the monitored parameters of HRV.

Of all the characteristics of the exercise intervention listed in TABLE 1 there was a correlation with the change in some of the HRV parameters (including the difference before and after exercise intervention) only in the case of the total duration of all of the aerobic parts of the training units (t_{EX}) and the average intensity of the exercise (% MHRR). These were mostly very low negative correlations between t_{EX} and the changes in LF/HF, VLF/HF, P_{VLF} and between % MHRR and the changes of VLF/LF, P_{VLF} a % VLF (TABLE 4).

Higher negative correlations were found among the most monitored parameters of HRV and their changes (TABLE 5).

TABLE 1
Qualitative and quantitative parameters of exercise intervention and maximal and resting heart rate

	n_{TR}	t_{EX}	t_{TR}	HRmax	HRrest	HR_X	% MHRR	t_{tHRopt}	t_{HRopt}
M	53.17	2284.07	42.92	176.25	63.43	133.30	62.60	1009.93	18.68
SD	13.26	577.66	0.77	13.41	7.35	9.64	7.24	466.10	6.40
Min.	9	383.03	40.31	108	48	103.40	49.26	130.75	6.23
Max.	73	3178.82	44.37	198	76	151.80	90.00	2448.97	42.96

Legend: n_{TR} – the number of training units, t_{EX} – total duration of all aerobic parts of training units (min), t_{TR} – duration of the aerobic part of the training unit (min), HRmax – maximum heart rate, HRrest – resting hear rate, HR_x – average heart rate in the aerobic part of training unit (min), % MHRR – average exercise intensity in % of maximum heart rate reserve, t_{tHRopt} – total duration of exercise in optimal HR (min), t_{HRopt} – duration of exercise in optimal HR, M – arithmetic mean, SD – standard deviation, Min. – minimum value, Max. – maximum value.

TABLE 2
Weight, BMI and maximal oxygen consumption (VO_2max) before and after the exercise intervention

	Before				After				Change		t-test
	M	SD	Min.	Max.	**M**	SD	Min.	Max.	**M**	SD	**p**
Weight [kg]	**72.08**	12.93	54.00	115.00	**71.05**	11.76	53.00	109.00	**–1.19**	3.7	0.021
BMI [kg.m^{-2}]	**26.18**	4.30	19.69	37.98	**25.80**	3.93	19.38	36.00	**–0.37**	1.03	0.020
VO_2max [l.min^{-1}]	**2.38**	0.42	1.64	3.22	**2.60**	0.42	1.78	3.50	**0.23**	0.23	0.000
VO_2max [ml.kg^{-1}.min^{-1}]	**33.32**	5.66	22.30	46.40	**36.99**	5.08	26.70	47.90	**3.67**	3.12	0.000

Legend: M – arithmetic mean, SD – standard deviation, Min. – minimum value, Max. – maximum value, Change – difference between value after and before exercise intervention, p – level of statistical significance (paired t-test).

TABLE 3
Selected parameters of HRV in the second supine position of supine-standing-supine test before and after exercise intervention

	Before				After				Change		t-test
	M	SD	Min.	Max.	**M**	SD	Min.	Max.	**M**	SD	**p**
TP [ms^2]	**1017.26**	829.86	114.28	3458.40	**976.36**	787.89	73.86	3342.85	**–40.90**	882.01	0.763
P_{VLF} [ms^2]	**217.47**	238.57	13.83	1214.29	**175.83**	179.53	15.82	950.68	**–41.64**	227.53	0.237
P_{LF} [ms^2]	**299.08**	291.85	20.04	1316.06	**291.04**	247.06	25.06	954.68	**–8.04**	283.15	0.853
P_{HF} [ms^2]	**500.71**	559.40	31.31	2839.67	**509.49**	561.37	6.42	2364.91	**8.78**	624.20	0.927
VLF/HF	**0.82**	1.12	0.06	6.74	**0.85**	1.62	0.02	8.93	**0.03**	1.05	0.866
LF/HF	**1.02**	1.00	0.12	4.71	**1.27**	1.56	0.05	6.66	**0.25**	1.36	0.239
VLF/LF	**1.03**	0.91	0.03	4.64	**0.87**	0.74	0.05	3.31	**–0.16**	0.79	0.205
% VLF	**23.42**	15.11	2.79	60.27	**20.12**	13.60	1.73	63.37	**–3.30**	13.86	0.126
% LF	**30.78**	16.70	9.53	80.28	**32.61**	19.21	4.34	79.76	**1.83**	16.60	0.473
% HF	**45.80**	20.76	8.77	82.11	**47.27**	22.08	6.88	93.93	**1.47**	21.68	0.660
RR [s]	**0.97**	0.12	0.76	1.26	**0.96**	0.14	0.70	1.30	**–0.01**	0.10	0.387
MSSD[ms^2]	**1568.10**	1637.26	130.06	7037.54	**1472.40**	1589.96	21.65	5760.11	**–95.70**	1785.73	0.727

Legend: M – arithmetic mean, SD – standard deviation, Min. – minimum value, Max. – maximum value, Change – difference between value after and before exercise intervention, p – level of statistical significance (paired t-test).

TABLE 4
Correlation between selected statistical characteristics of exercise intervention (parameters of adherence to exercise) and the changes in monitored HRV parameters

	t_{EX}		% MTR	
	r_p	P	r_p	p
RTP [ms²]	−0.20	0.208	−0.15	0.331
RP_{VLF} [ms²]	**−0.30**	**0.050**	**−0.33**	**0.036**
RP_{LF} [ms²]	−0.22	0.162	−0.07	0.678
RP_{HF} [ms²]	−0.07	0.662	−0.07	0.666
RVLF/HF	**−0.39**	**0.011**	−0.21	0.174
RLF/HF	**−0.51**	**0.001**	−0.08	0.609
RVLF/LF	0.02	0.914	**−0.49**	**0.001**
R %VLF	−0.23	0.145	**−0.34**	**0.026**
R %LF	−0.20	0.214	0.04	0.815
R %HF	0.30	0.057	0.19	0.225
RR [s]	0.02	0.904	−0.01	0.941
MSSD [ms²]	0.05	0.766	−0.16	0.321

Legend: R – change (difference of the value after and before exercise intervention), t_{EX} – total duration of all aerobic parts of training units, % MHRR – average intensity of the exercise, r_p – Pearson's correlation coefficient, p – level of statistical significance.

TABLE 5
Correlation of changes in HRV parameters with their initial values

	r_p	p
TP [ms²]	**−0.58**	**0.000**
P_{VLF} [ms²]	**−0.70**	**0.000**
P_{LF} [ms²]	**−0.63**	**0.000**
P_{HF} [ms²]	**−0.55**	**0.000**
VLF/HF	0.12	0.463
LF/HF	−0.15	0.349
VLF/LF	**−0.64**	**0.000**
% VLF	**−0.56**	**0.000**
% LF	**−0.33**	**0.028**
% HF	**−0.46**	**0.002**
RR [s]	−0.21	0.184
MSSD [ms²]	**−0.57**	**0.000**

Legend: r_p – Pearson's correlation coefficient, p – level of statistical significance.

DISCUSSION

The main aim of this exercise intervention was not reduction of weight (the initial values of BMI were 26.2 ± 4.3 kg.m^{-2} and in most women, under 25 kg.m^{-2}), therefore a statically but not logically significant decline on the average of 1 kg occurred. However, the average value of the BMI of the whole tested group persisted in the overweight range (25.8 ± 3.93 kg.m^{-2}). These changes in body weight were accompanied by a statically significant increase in aerobic fitness expressed by the use of VO_2max, namely almost about 3.5 ml.kg^{-1}.min^{-1}, that is by about 1 MET. A more detailed analysis of changes in weight and other morphological and functional parameters are not included in this paper.

The main aim of the study was to assess how changes in HRV are possibly related to exercise intervention adherence. That is why exercise attendance was not influenced in any way and the frequency of exercise was absolutely up to the women's will. We hypothesized that big differences in adherence will help to identify its effect better.

Great differences in the qualitative as well as in the quantitative characteristics of exercise intervention were mainly caused by multidimensional psychological factors such as motivational orientation, motivational atmosphere, persistent personal features (self-discipline, self-control, resolution, diligence, ambitions, competition, ability to concentrate, pride in achievement, etc.), satisfaction with the stated aims of the exercise (improvement of health or fitness, reduction of body mass, body shaping, etc.), further satisfaction with group cohesiveness, with sport medical histories, etc. However, an analysis of these factors is not the aim of this study. Illness, work and family problems influenced their adherence as well as the above- mentioned psychological factors.

Other reasons which could influence the changes in HRV after the exercise intervention could be the age and initial fitness of the women. That is why there is such a relatively extensive range of age in the study (25 years) and it could be one of the reasons for the low degree of homogeneity from the point of view of aerobic power (the maximum difference in VO_2max was 24.1 $ml.kg^{-1}.min^{-1}$). However, our correlation analysis did not prove any significant relation between the age of our subjects and the parameters of HRV nor their changes after program. The results of other studies are not the same from this point of view. According to some authors, aerobic training positively improves HRV similarly both in younger and in older persons (Stein et al., 1999). Other authors say that the impact of aerobic training is augmented in younger people as compared to older people (Carter, Banister, & Blaber, 2003), but opposing evidence exists as well (Leicht, Allen, & Hoey, 2003; Levy et al., 1998).

The average exercise intensity of subjects in the aerobic part of the exercise program was relatively low (62.6 ± 7.3% MHRR). This exercise intervention caused an increase in aerobic power, but did not influence any of the monitored parameters of HRV significantly. The results do not correspond to the studies showing that regular aerobic training increases the vagal modulation of the heart already in a few weeks or months (Esperer, 2006; Hottenrott, Hoos, & Levy et al., 1998; Lee, Wood, & Welsch, 2003). On the contrary, other studies did not confirm any positive effect of aerobic training on HRV (Boutcher & Stein, 1995; Davy, Willis, & Seals, 1997; Degeus et al., 1996; Maciel et al., 1985). A fundamental difference among the quoted studies is the exercise intensity used. The studies which illustrated an increase in vagal modulation have mostly used a higher exercise intensity (at about 80% MHRR) (Lee, Wood, & Welsch, 2003). On the contrary, the studies showing no effect of exercise on the functional state of the autonomic nervous system have used a lower intensity (at about 60% MHRR). For example, Boutcher and Stein (1995,) after three months of a mild aerobic exercise (20–30 min., 60% MHRR, 3 times per week, 24 training units), found increased aerobic power, however no change in HRV. Similar evidence is given by other authors who prescribed an aerobic exercise of mild intensity with a duration of from eight to twelve weeks (Davy, Willis, & Seals, 1997; Maciel et al., 1985) or a few months of mild intensity (Degeus et al., 1996) to people with a sedentary lifestyle.

It seems that, apart from the others, the positive effect of a long term exercise on ANS depends on the exercise intensity, but it is not possible to set up a uniform level of the exercise intensity which might influence the activity of ANS as it was shown in the literature. People with lower aerobic stength can achieve positive effects using relatively and absolutely lower exercise intensity than people with higher aerobic power. This means that the exercise intensity which is good for people with lower aerobic power is ineffective for those with higher aerobic power.

Aerobically trained individuals with higher aerobic power usually have higher vagal activity, which means higher ANS activity (DeMeersman, 1993; Leicht, Allen, & Hoey, 2003). On the contrary, those with a sedentary lifestyle (consequently with lower aerobic power) have lower ANS activity (Dixon, Kamath, McKartney, & Fallen, 1992). Among the people with lower aerobic power, a low exercise intensity is more effective in influencing ANS than among people with higher aerobic power, thus the so called law of "initial values" (Sandercock, Bromley, & Brodie, 2005) should be valid for exercise intervention with a relatively low intensity: the lower the initial activity of ANS, the greater its increase.

This consideration was confirmed in the tested group with the use of a correlation between the initial values of HRV parameters and differences between the terminal and initial values of these parameters. All of the correlation coefficients were negative and most of them confirmed the supposed relationship. It is obvious that exercise intervention in the women with the lowest ANS activity caused the increase in spectral power, especially in the lower part of the spectrum. Inversely, women with higher initial values of HRV parameters displayed a lower increase and even a decrease of the parameters.

The initial levels of ANS activities were under the influence of various factors which influenced the women differently. Aside from genetic factors (Singh et al., 1999), chronic mental stress and other psychological factors (Lackschewitz, Hüther, & Kröner-Herwig, 2008) it is mainly age (Task Force, 1996), health status (Cowan, 1995; Stejskal & Salinger, 1996), and regular exercise and/or life style (Migliaro et al., 2001). The correlation analysis indicated that the exercise intervention used especially influenced the part of the power spectrum which is less under the influence of the vagal and sympathetic (mainly VLF component) in women with low ANS activity. As the final examination of ANS was carried out in some women on the first day after the last training session, it is not possible to exclude that the result of ANS measurement was not influenced by this fact. The parameters of HRV representing vagal activity show a slower gradual restoration after the cessation of exercise than parameters representing sympathetic activity or, better said, a sympatho-vagal balance (Jakubec, 2005). Sympathetic activity predominates over vagal activity during the time of recovery after the exercise. It is not possible to exclude that a later measurement (one or two days later) would show higher values of $P_{HF,}$ especially in women with low initial values. This would cause a change in spectral power on behalf of vagal activity.

Taking into account great differences in adherence to the exercise intervention program, we expected that the relationship between the volume of exercise and/or the quality of exercise and changes in HRV parameters would be clearly confirmed, but of all the monitored qualitative and quantitative parameters of exercise intervention, only t_{EX} (total duration of all the aerobic part of the training units) and % of MHRR (average exercise intensity) correlated with the changes of some of the HRV parameters. The values of the correlation coefficients were much lower than those for the initial values and changes in the parameters of HRV. All significant correlations were negative and were found in the spectral power of VLF and in ratios. It follows from these analyses that, in women with higher adherence to the programme, the values of P_{VLF}, VLF/HF and LF/HF were more likely to decrease, while in women with lower adherence they were more likely to increase. The women with higher exercise intensity during aerobics were more likely to show a decrease in P_{VLF}, % VLF and VLF/HF; in the women with lower exercise intensity the converse was true. From these results it seems that the volume and the quality of the exercise were more likely to be displayed in changes of the distribution of spectral power than in its volume. These changes can be indicated as positive because they show a shift in the direction of spectral power towards the parasympathetic.

From the comparison of levels of correlation coefficients for the impact of exercise intervention and for the impact of the initial level of HRV parameters, it is clear that the impact of the volume and the quality of the exercise intervention were strongly suppressed by the impact of the initial level of ANS activity. This results of correlation analyses should be taken into consideration both while comparing the effects of different kinds of exercise and while searching for optimal exercise intervention programmes. If the exercise is to have a positive effect on ANS activity, then its intensity should be adapted to the aerobic power of each subject. It can not be expected that exercise intervention with lower exercise intensity will cause an increase of their ANS activity in subjects with markedly higher aerobic power.

From this point of view, using dance or step-dance aerobics is problematic, because a higher intensity of the exercise is suppressed mostly by poor technique, because of frequent changes of choreography and in many cases by a poor ability to carry out an intensive dance performance. That is why dance or step-dance aerobics should serve as a suitable exercise activity rather for subjects with lower aerobic power. For subjects with higher aerobic power or with higher endurance ability it might serve as an optimal exercise activity after some time, but not until the technique problems are removed and identification with the pace and rhythm of the music is presented. It seems that the necessary time period of time for middle aged and younger women is longer than six months.

CONCLUSIONS

Great differences in adherence to the six month training period of dance and step-dance aerobics were not significantly displayed in the activity of the autonomic nervous system assessed with the use of the spectral analysis method of heart rate variability. Correlation analyses suggested that the shift of spectral power from sympathetic to parasympathetic happened in the women with a higher adherence to the programme. But it was shown that the influence of the volume and quality of exercise were suppressed by the initial level of each parameter of HRV. The lower (worse) the initial values of these parameters were before starting the programme, the greater were their increases in half a year's time. With regards to the relationship between aerobic power and ANS activity, it is possible to state that, in light of the impact on ANS activity, dance or step-dance aerobics could serve as a suitable exercise activity more for subjects with lower aerobic power. A necessary condition for the general use of aerobics is to master technique connected with frequent changes of choreography and with the ability to manifest the rhythm of the music by dancing. Under these conditions it is possible to increase the exercise intensity and thus to extend the spectrum of subjects for whom this exercise will increase the activity of their ANS.

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ZMĚNY VARIABILITY SRDEČNÍ FREKVENCE PO ŠESTIMĚSÍČNÍM PROGRAMU TANEČNÍHO A STEP AEROBIKU U ŽEN VE VĚKU 40–65 LET: VLIV ROZDÍLNÉ ADHERENCE, INTENZITY A INICIÁLNÍCH ÚROVNÍ

(Souhrn anglického textu)

Cílem předkládané studie bylo zjistit, jak jsou změny variability srdeční frekvence (HRV) po šestiměsíčním programu tanečního a step aerobiku ovlivněny adherencí, intenzitou zatížení a vstupní úrovní HRV. Testovanou skupinu tvořilo 44 žen ve věku 47,35 ± 5,4 let. Použité metody byly spektrální analýza krátkodobých záznamů R–R intervalů a chodecký/běžecký test do maxima na běžeckém pásu s postupně narůstajícím sklonem. Intervence: skupinové cvičení aerobiku, šest měsíců, třikrát týdně, 40–45 minut. Intenzita zatížení byla monitorována pomocí monitorů srdeční frekvence. Výsledky: velké rozdíly mezi ženami byly v počtu absolvovaných cvičebních jednotek (9–73). Průměrná hmotnost probandek se snížila z 72,1 ± 12,9 kg na 71,1 ± 11,8 kg a průměrná VO_2max se zvýšila z 33,3 ± 5,7 ml.kg^{-1}.min^{-1} na 37,0 ± 5,1 ml.kg^{-1}.min^{-1}. Pohybová intervence nevedla k žádným statisticky významným změnám sledovaných ukazatelů HRV. Pouze dvě charakteristiky pohybové intervence (celkové trvání aerobních částí cvičebních jednotek a průměrná intenzita zatížení) korelovaly se změnami HRV. Negativní korelace byla zjištěna mezi většinou sledovaných ukazatelů HRV a jejich změnami. Korelační analýza u žen s vyšší adherencí k programu naznačila mírný posun spektrálního výkonu směrem od sympatiku k parasympatiku. Ukázalo se však, že vliv objemu a kvality cvičení byl výrazně potlačen vlivem vstupní úrovně jednotlivých ukazatelů HRV. Čím nižší (horší) byly hodnoty těchto ukazatelů před pohybovou intervencí, tím větší byl jejich vzestup (zlepšení) za půl roku. Vzhledem ke vztahu mezi aerobní kapacitou a aktivitou ANS lze konstatovat, že z hlediska vlivu na aktivitu ANS je aerobik vhodnou pohybovou aktivitou spíše pro osoby s nižší aerobní kapacitou.

Klíčová slova: variabilita srdeční frekvence, adherence, iniciální hodnoty, taneční a step aerobik.

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THE EFFECTIVENESS OF SPECIFIC PHYSIOTHERAPY IN THE TREATMENT OF TEMPOROMANDIBULAR DISORDERS

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The aim of this study was to evaluate the effect of individual specific physiotherapy in the treatment of temporomandibular disorders, its immediate effect and its effect after two months. The research sample was comprised of 23 subjects, 17 women and 6 men, with an average age of 36.5 years. They complained of pain, sound phenomena and restricted mandibular movements. The patients were first examined by a stomatologist who recommended physiotherapy. The effect of treatment was assessed according to the intensity of pain, the occurrence of reflex changes in soft tissues in the region of the masticatory muscles and digastricus muscle, the range of mouth opening and the intensity of sounds produced by mandibular movements. It was found that after treatment pain was significantly reduced ($p < 0.001$) at the temporomandibular joint (from 4.2 points to 0.7 point on the VAS). There were also fewer reflex changes in the muscles and fascias. The range of mouth opening increased significantly (from 37.3 mm to 41.3 mm, $p < 0.001$) and the intensity of sounds was reduced from 100% to 43% ($p < 0.001$). The finding shows that this state was maintained two months later: intensity of pain ($p < 0.001$), mouth opening ($p < 0.003$) and reduction of sound phenomena ($p < 0.001$). Pain was ameliorated, the intensity of sounds reduced, and the range of movement significantly improved after specific physiotherapy.

Keywords: Temporomandibular joint, temporomandibular disorder, individual physiotherapy.

INTRODUCTION

The temporomandibular joint (TMJ) is one of the most frequently used joints of the human body. It is used when speaking, chewing, yawning, swallowing and other activities during the day and even in sleep. The frequency of movement is assessed as approximately 1500–2000 times a day (Hoppenfeld, 1976; Magee, 2002). The coordination of the mandibula and the maxilla with both the dental arches, the masticatory muscles with the activity of the neck muscles with their receptors in the periodontium, periost, in the muscles and joint capsules form an integrated harmonious unit. Its function is controlled by the central nervous system (CNS) (Bourbon, 1995). The primary disorder can originate at any level of this complex and cause its dysfunction. In the greatest number of cases the cause is a disturbance of function in the form of increased muscular tonus and myofascial trigger points (TrPs). It is essential to start treatment at the stage of mere dysfunction, i. e. at the stage when the changes are still reversible, in order to prevent irreversible structural changes.

The term "temporomandibular disorder" (TMD) stands for a number of disorders related to the masticatory muscles or the TMJs and related structures (Zemen, 1999).

According to epidemiological statistics, 70% of the randomized population suffers from at least one symptom or sign of TMD, but only one fourth of this number is aware of it and only 5% seek medical treatment (Dimitroulis, 1998; Pedroni, De Oliveira, & Guaratini, 2003).

AIM

The purpose of the paper is not only to demonstrate the effect and duration of specific individual physiotherapy. It is also to show some factors causing TMD, the percentage of individual symptoms and signs related to pain, the presence of reflex changes in soft tissues, sound phenomena and disturbed mobility of the mandible in our patients at the beginning and at the end of the treatment.

METHODS

Participants

The 23 subjects who sought treatment at the Department of Oral and Mandibular Surgery of the Faculty Hospital in Olomouc were included in the research sample. They complained of pain, sound phenomena and restricted mandibular movements. They were accepted for treatment during the period from October to December 2005. The patients were first examined by a stomatologist who recommended physiotherapy.

The group consisted of 17 women and 6 men. Their average age was 36.5 years. The average age of the women was 39.2 years, and of the men, 30.4 years. Informed consent was obtained from each patient.

Examination protocol

The most important symptoms of TMD and anamnestic/medical historical data about the duration of the complaints and possible provocative factors were assessed with a questionnaire. In addition to pain, sounds, movement restriction and other symptoms, such as instability of the TMJ, disturbance of hearing (tinnitus, a one sided loss of hearing), dizziness, vertigo, dysphagia, toothache, or increased dental sensitivity without true stomatological signs were identified. Anamnestic/medical historical data focused mainly on the duration of persisting problems, their location, the presence of bruxism, stress and mental tension. Previous dental treatment was of special interest as was the history of trauma to the mandible, head and neck.

The patients drew a picture of their pain, its site and irradiation. They were asked what aggravated and what relieved it, a possible circadian rhythm of pain and its intensity according to a scale from 0 to 10 (Visual Analogue Scale – VAS). This was evaluated at the beginning and the end of the treatment.

To assess the range of the mouth opening, the patient placed three knuckles, preferably of the non dominant hand, between the upper and lower incisors (Travell & Simons, 1998). For more exact measurements a slide gauge was used to measure the range of mandibular movement. In particular the distance between the centres of the upper and lower incisors was measured in millimetres with the mouth wide open. These tests were carried out before and after the treatment.

Each patient described what was subjectively heard when moving his/her jaw. The examination determines whether an audible click is heard at the start of the process of the opening of the mouth, in the course thereof or at the end or on closing the mouth. The intensity of the sound was described according to a scale from 0–3 (0 = no sound, 1 = minimal click, 2 = causing discomfort, 3 = audible to others, causing severe discomfort). This, too, was assessed at the beginning and at the end of the treatment. To evaluate the results of the treatment, the intensity of the sound was considered at the beginning to be 100% and was compared to the intensity at the end in percentages.

The examination of the TMJ covers active movement, joint play, the direction in which the incisors move and palpation of the TMJ and the hyoid. The soft tissues involved are also examined (the masticatory muscles, the digastricus and mylohyoideus, the neck muscles and also the fascias and scalp). The cervical spine was examined as well.

Physiotherapeutic protocol

Individual physiotherapy was given in ten sessions which included soft tissue and mobilisation techniques and therapeutic exercise under the guidance of an experienced physiotherapist. Each session lasted 30 minutes and was practiced twice a week for five weeks. A control examination took place after two months in 10 patients in order to verify a more lasting effect. In the course of the treatment, the method was tailored to the individual findings and the needs of the patient. As a rule, physiotherapy for TMD patients proceeds in the following three stages:

During the first stage, the physiotherapist gives instructions to and explains to the patients the symptoms, the causes and consequences of his/her problems and the therapeutic options. This relieves the patient's uncertainty and apprehensions which might complicate the treatment. In this way, the patient's confidence, so essential for a successful treatment, is obtained. The main object of this first stage is to find the principal factors which perpetuate the condition and to teach the patient how to deal with them. The patient learns what the bad habits are which overstrain the TMJ and how to eliminate them. These factors include finely cut and soft food, chewing food symmetrically on both sides, and insufficient opening of the mouth in the pain free range, especially when yawning (Michelotti, de Wijer, Steenks, & Farella, 2005).

The objective of the second stage is to normalize the range of movement of the TMJ and the soft tissue tension in the entire region of the head and neck. Fascias were treated by myofascial release techniques according to Greenman (1996), myofascial trigger points and muscle spasm by post isometric relaxation (PIR) according to Lewit (2003) and "trigger point pressure release" according to Mense and Simons (2001). Soft tissue treatment was repeated until no pathological resistance against shifting or stretching, i. e. normalisation of pathological barriers, could be felt. Care was taken not to increase any pain in the course of soft tissue treatment. The normal range of the mouth's opening was obtained by mobilisation according to Hengeveld and Banks (2005). The hyoid was mobilised by PIR according to Lewit (2003).

The objective of the third stage is to train coordination, in particular the stereotype of mandibular abduction and adduction. This is achieved by eliminating the deviation of the chin's position and reducing the mouth opening in case of hypermobility. Specifically, the patients learn how to control the position of the mandibula at rest, to activate the depressors of the mandible and its retrusion and to perform a controlled rotation of the condyles. A further objective is stabilisation by means of strengthening weak muscles, preferably using diagonal movements for both coordination and strength. All the exercises were initially repeated 3–5 times and the number of repetitions was gradually increased up to 10. The movement was carried out in such a way so as not to cause pain and sound phenomena. Further details about the practical aspects of the exercises were published by Velebová and Smékal (2007).

Statistics

The data from the measurements were processed using the "Statistica 6.0" programme. Basic statistical values (arithmetic averages, medians, standard deviations and quartile ranges) were obtained in this way. Based on angularity and acuteness, a corresponding test for the comparison of the data was selected. The Wilcox pair test, a non parametric test of two variables, was used for the evaluation of the data (the intensity of pain in the region of the TMJ, the range of movement and the intensity of sounds) for the entire group. Friedmann's ANOVA and Kendall's conformity coefficient, a non parametric test of several dependent variables, were used to assess the data two weeks after the treatment.

RESULTS

The most important anamnestic/medical historical factor in the development of TMD was dental treatment, 43.5%, followed by emotional stress, 39.1% and oral parafunctional occlusal contact, 34.8% (Fig. 1).

Predisposition to TMD was higher in students and pupils than in any other group of the population (Fig. 2). The most frequent initial symptoms were sound phenomena 95.7%, pain 82.6%, and stiffness or restricted mandibular movements 69.6% (Fig. 3). Further TMD symptoms were toothache without stomatological cause, 47.8%, auditory problems such as tinnitus and unilaterally reduced hearing, 47.8%, dysphagia, non inflammatory pain in the throat, a feeling of instability upon maximum opening of the mouth or during fast mandibular movement, 34.8%, and dizziness 17.4% (Fig. 3).

The most frequent reflex changes were found in the masseters, 91.3% before and 47.8% after the treatment. The second most frequently affected muscle was the pterygoideus lateralis muscle, 89.1%, which dropped to 56.5% after the treatment. In 67.4% of the cases, the pterygoideus medialis muscle was affected before the treatment and after the treatment by 10.9%. The temporalis muscle showed reflex changes only in 26.1% of the cases before and in 15.2% of the cases after treatment. The smallest number of changes was found in the digastricus muscle in 13% of the cases, both in its venter anterior and posterior positions. This dropped to 6.5% after the treatment (Fig. 4).

Reflex changes in galea aponeurotica were found in 65.2% of the cases and after the treatment in 17.4% of the cases. Changes were found in the pretracheal fascia of the neck on the right, 56.5%, and on the left, 34.8%, before and 26.1% on the right and 21.7% on the left after treatment. Restriction of functional movement on the right side of the hyoid was found in 56.5% of the cases before the therapy and in 21.7% of the cases after the therapy. Restriction of the functional movement of the left side of the hyoid was found in 34.8% of the cases and after the therapy the number decreased down to 4.4% (Fig. 5).

In the course of treatment patients experienced a statistically significant reduction of the intensity of pain, from the initial 4.2 points to 0.7 at the end, i.e. by 3.5 points ($p = 0.0013$ by the Wilcox matched pair test).

A statistically significant increase in the range of mandibular abduction was also achieved by individual physiotherapy from an initial average of 37.3 mm to a final 41.3 mm, i.e. an increase of 4 mm ($p = 0.0002$ by the Wilcox matched pair test).

During mandibular movement, a statistically significant reduction of sound phenomena by 57% was achieved. Their intensity decreased from an original 100% to 43%. This result was significant ($p = 0.0002$) according to the Wilcox pair test.

Symptoms improved or disappeared after the treatment in 96% of the cases (Fig. 6).

This effect was shown in 10 cases 2 months after the treatment. Pain at the TMJ decreased from an average of 5.8 points to 1.1 points after the treatment and to 0.4 points after two months. This difference was significant at a level of $p = 0.0009$ according to Friedmann's ANOVA.

The abduction range of the TMJ increased in this group from 37.6 to 41.1 mm at the end of the treatment and was 44.7 mm after two months. This difference was significant ($p = 0.0021$ according to ANOVA).

The intensity of sound phenomena decreased from an original of 100% to 29.5% at the end of the treatment and was 16% after two months. This difference was significant ($p = 0.0001$ according to ANOVA).

Fig. 1
Etiological factors of temporomandibular disorder

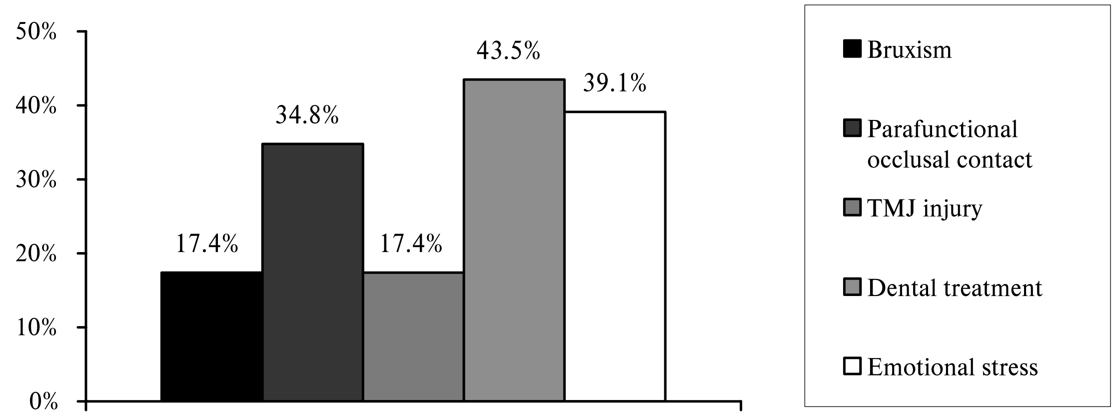


Fig. 2
Predisposition to temporomandibular disorder in different groups of the population

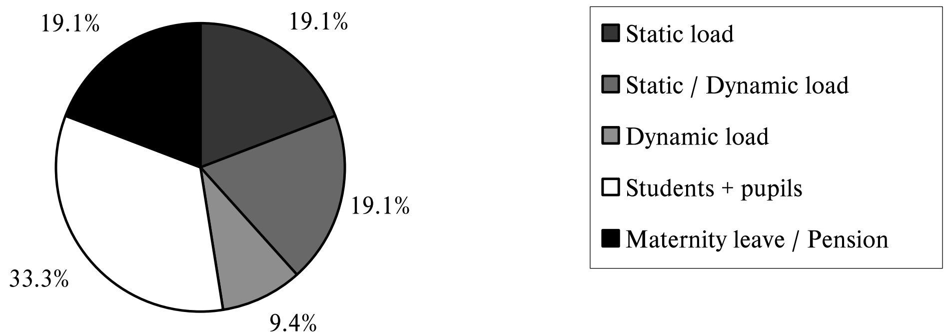


Fig. 3
Distribution of symptoms of temporomandibular disease before and after therapy

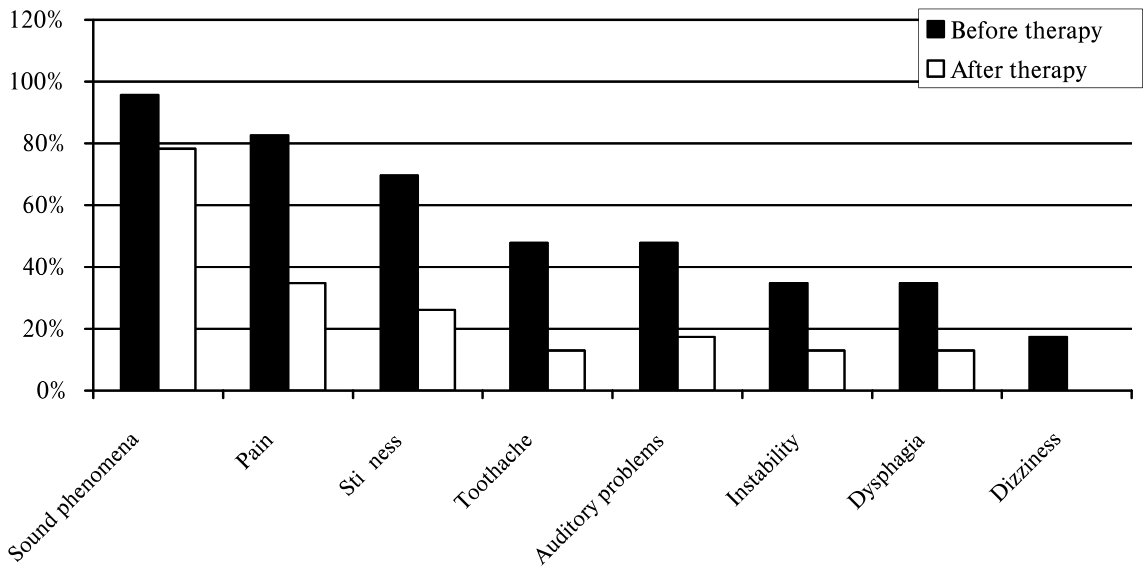
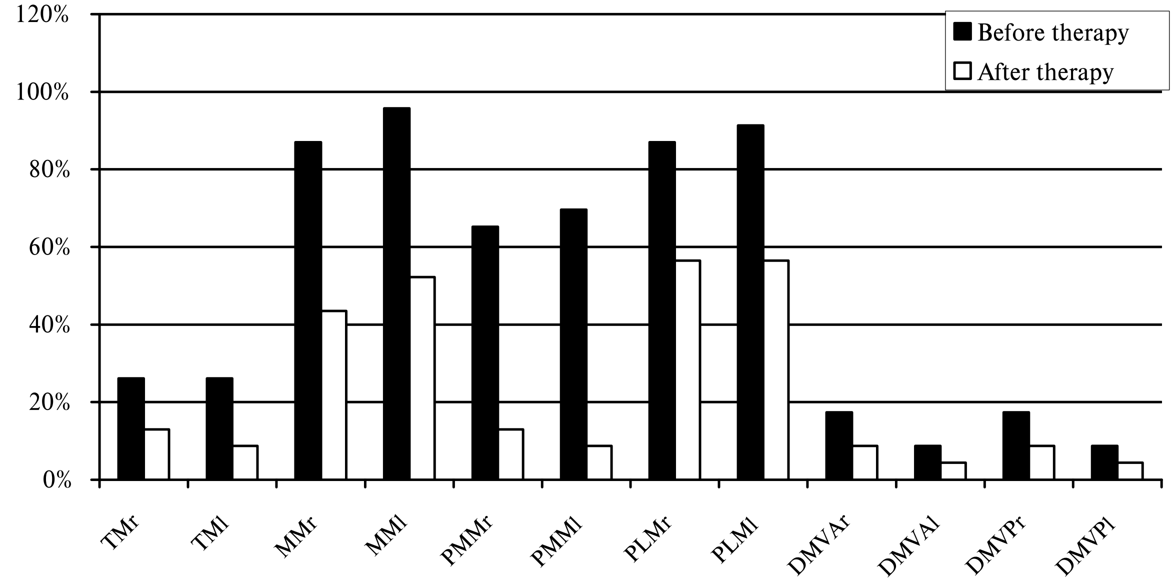
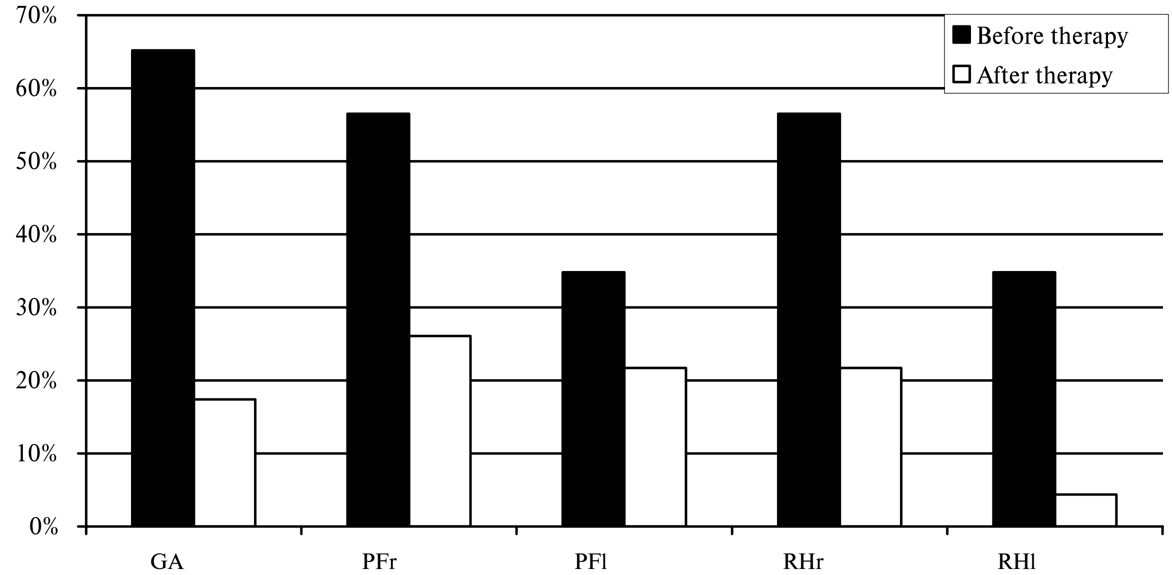


Fig. 4
Reflex changes in masticatory muscles before and after therapy



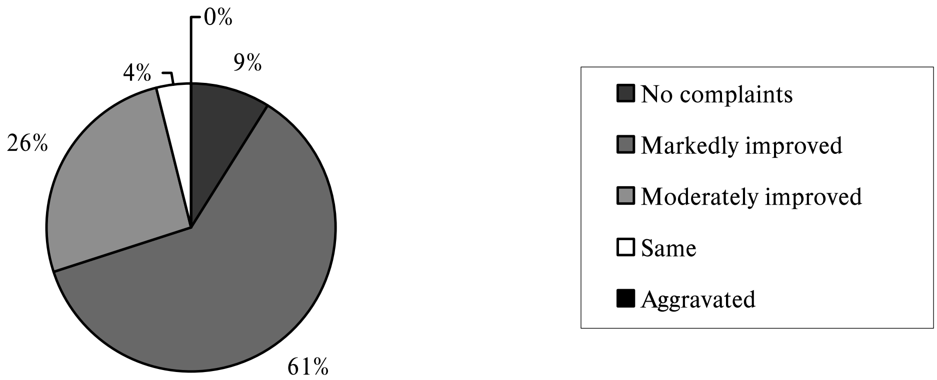
Legend: TMr – Temporalis muscle (right), TMl – Temporalis muscle (left), MMr – Masseter muscle (right), MMl – Masseter muscle (left), PMMr – Pterygoideus medialis muscle (right), PMMl – Pterygoideus medialis muscle (left), PLMr – Pterygoideus lateralis muscle (right), PLMl – Pterygoideus lateralis muscle (left), DMVAr – Digastricus muscle – venter anterior (right), DMVAl – Digastricus muscle – venter anterior (left), DMVPr – Digastricus muscle – venter posterior (right), DMVPl – Digastricus muscle – venter posterior (left).

Fig. 5
Reflex changes in fascias and restriction of movement of the hyoid before and after therapy



Legend: GA – Galea aponeurotica, PFr – Pretracheal fascia (right), PFl – Pretracheal fascia (left), RHr – Restriction of hyoid (right), RHl – Restriction of hyoid (left).

Fig. 6
Subjective assessment of the effect of specific physiotherapy by the patients



DISCUSSION

Anamnestic/medical historical data show that TMD develops most frequently after stomatological treatment during which the mouth was held wide open (e.g. extraction of molars, orthodontic interventions or dental implants). Early treatment not only clears up the disturbance but prevents deterioration and chronicity. Repeated stomatological treatment and/or keeping the mouth open for prolonged periods is a risk factor producing TMD (Hengeveld & Banks, 2005). The second most frequent factor was stress and psychological tension (Dimitroulis, 1998; Machoň & Lukášová, 2005; Pallegama, Ranasinghe, Weerasinghe, & Sitheeque, 2005; Velly, Gornitsky, & Philippe, 2002). In such cases the best treatment therefore is psychotherapy and individual physiotherapy with a sensitive approach to the patient. The third most frequent cause of TMD was a parafunctional disorder with occlusal contact. This is in agreement with the findings of other authors (Miyake, Ohkubo, Takehara, & Morita, 2004).

Parafunctional activities traumatize the TMJ and cause an increased activity and tension in the masticatory muscles with reflex changes and pain. In this way a vicious circle is established. This can be overcome by changing the patient's behaviour by self monitoring and by treatment which reduces muscular as well as mental tension due to parafunctional activity. The effect of the treatment was particularly striking in two patients after fracture of the mandible whose pain was dramatically reduced and the range of the mouth opening increased. Bruxism as an etiological factor in TMD was present only in 17.4% of the cases. This is in agreement with the literature (Machoň & Lukášová, 2005). It may be due to the fact that the patients are not aware of it.

The largest group of patients was made up of students and school children – 33.3%. This can be due to increased stress, especially in university students and in younger children during puberty or as a consequence of orthodontic treatment. Of patients, 19% were office workers, 19% had a job in which static and dynamic work was balanced and only 9.5% were physically active at work. Work under mainly static conditions, sitting with a forward drawn head and neck had no apparent effect on TMD. In women on maternity leave, hormonal changes may play a role and in the elderly, arthrotic changes at the TMJ may be implicated.

The most frequent symptoms in our patients were sound phenomena with a 95.6% occurence. They were of various origin and character. Some were absolutely benign, in particular as an isolated symptom without pain and movement restriction (Dimitroulis, 1998). Pain was the second most frequent symptom in 82.6% of the cases.

The most frequent reflex changes (trigger points – TrPs, tender points – TePs) in our group were found in the masseter muscle (in 91.3%), followed by the pterygoideus lateralis muscle (89.1%) and the pterygoideus medialis muscle (in 67.4%). This is in contrast with the study of Travell and Simons (1998) who found TrPs most frequently in the pterygoideus lateralis muscle (36%), in the pterygoideus medialis muscle (17%) and in the masseter muscle only up to 3%. This difference may be due to different pressure applied for palpation or different assessment of the taut band, TePs and TrPs.

The examination of soft tissue and mobility showed that there was a correlation between changes in the pretracheal fascia and the side of restricted movement of the hyoid. The movement of the hyoid was restricted towards the side opposite to the taut fascia. There was also a correlation between the side of atlanto-occipital (AO) movement restriction and a restriction barrier of the TMJ – TMJ was more frequently on the left. We can argue that there was a link between AO and TMJ movement restriction.

According to Travell and Simons (1998) myofascial trigger points are the most frequent cause of pain in the region of the TMJ. This was confirmed by our patients in whom compression of TrPs produced pain which corresponded to their spontaneous pain. This is further borne out by a reduction of pain from 4.2 to 0.7 points and by the cessation of tooth ache without stomatological cause which was reduced from the initial 47.8% to 13% after the treatment. It may be useful for stomatologists to know about painful changes in function. These are frequently ignored and the patient's pain of muscular origin is overlooked.

Restricted mobility of the mandible may be caused by an increased tension in the masticatory muscles or by a dislocation of the intraarticular disc, its anterior position interfering with the anterior glide of the mandibular condyles during opening of the mouth (Magee, 2002; Travell & Simons, 1998).

A high percentage of the patients suffered from a disturbance of hearing – tinnitus (ringing in the ears) and of one sided deafness. This may be caused by myofascial pain or by biomechanical changes in the mandibulocranial complex. If there are changes in the character and intensity of the tinnitus during mandibular movements, physiotherapy is likely to produce good results (Koneke C., Koneke A., Mangold, & Nowak, 2005).

A striking reduction of pain was achieved exclusively by manual mobilization, relaxation and soft tissue techniques applied to the TMJ, the cervical spine and its fascias, without drugs or other means of physical therapy. These techniques by themselves seem to have abolished the increased tension of the soft tissues in the region of the TMJ. Another important role is played by the elimination of pathogenetic factors causing pain by means of self control. This is also pointed out in recent studies (Hanáková, Jureček, & Konečný, 2005; Michelotti el al., 2005; Nicolakis et al., 2001; Nicolakis et al., 2002; Oh, Kim, & Lee, 2002) according to which the best biomechanical conditions can be achieved by relaxation, coordination and stabilization training.

The normal range of mouth opening is usually considered to be 35–50 mm (Gallagher C., Gallagher V., Whelton, & Cronin, 2004; Hoppenfeld, 1976; Magee, 2002). Less than 35 mm must be considered hypomobile, whereas more than 50 mm as hypermobile. The smallest range in our group was 18 mm which improved to 23 mm after the treatment. On the average the range of movement increased by 4.09 mm. Physiotherapy thus increases also the range of mandibular movement which is also born out by the literature (Hanáková, Jureček, & Konečný, 2005; Nicolakis et al., 2001, 2002; Oh, Kim, & Lee, 2002).

The effectivity of the treatment on the sounds produced by movements of the mandibula was clearly shown. These ceased completely in 18% of the cases while in the majority of cases the character of the sounds changed and the intensity of the sounds and the clicking were reduced and their frequency diminished, to the effect that they disappeared nearly completely at the time of mouth opening. The intensity of the sound phenomena was reduced by 56.7%.

After the treatment, 8.7% of the patients were entirely symptom free, 60.9% of them were very satisfied with individual physiotherapy, 26.1% indicated moderate improvement and 4.3% felt no change. Deterioration did not occur in any case. Improvement was thus achieved in 95.7% of the cases, with only 4.3% of them being neutral cases.

The improvement two months after the treatment and even further progress in some cases can be ascribed to continued home exercise, to consistent adherence to a healthy regimen producing further decrease of the tension in the region of the TMJ.

CONCLUSION

We found that physiotherapy is useful in treating TMD. The favourable results of this study are in agreement with data from the literature, where similar effects of relaxation, coordination and stabilization exercise of the TMJ are mentioned (Hanáková, Jureček, & Konečný, 2005; Michelotti et al., 2005; Nicolakis et al., 2001, 2002; Oh, Kim, & Lee, 2002). Individual physiotherapy in the early stages of dysfunction is the best prevention of a chronic course due to structural pathology. The treatment should not be limited to the region of the TMJ, but should take into account its relationship to other parts of the motoric system owing to chain reactions occurring in the motoric system as a rule. Dysfunctional chains have their key links which can be outside the orofacial system and may even cause TMD. This is important for the prevention of relapses.

ACKNOWLEDGMENT

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EFEKT CÍLENÉ REHABILITAČNÍ INTERVENCE PŘI LÉČBĚ TEMPOROMANDIBULÁRNÍCH PORUCH

(Souhrn anglického textu)

Cílem práce bylo zhodnotit vliv individuální fyzioterapie temporomandibulárních poruch (TMP) a ověřit trvání efektu terapie u těchto potíží po dvou měsících od ukončení individuální fyzioterapie. Bylo vyšetřeno 23 probandů, 17 žen a 6 mužů, s průměrným věkem 36,5 roku. Hodnocena byla účinnost individuální fyzioterapie na výskyt a intenzitu bolesti v oblasti temporomandibulárního kloubu (TMK), na rozsah abdukce v čelistním kloubu a na intenzitu zvukových fenoménů při pohybech dolní čelisti. Pacient byl nejdříve vyšetřen stomatologem, který po vyšetření doporučil individuální fyzioterapii. Efekt individuální fyzioterapie byl posuzován na změnách intenzity bolesti, na přítomnosti nebo absenci reflexních změn v měkkých tkáních žvýkacích svalů a m. digastricus, na změně velikosti otevírání úst a na intenzitě zvukových fenoménů při pohybech dolní čelisti. Po ukončení terapie jsme zjistili, že individuální fyzioterapie u TMP vede ke statisticky významnému ($p < 0{,}001$) snížení subjektivně vnímané intenzity bolesti v TMK – z 4,2 bodu na vizuální analogové škále (VAS) na 0,7 bodu. Došlo také ke snížení počtu reflexních změn ve svalech a fasciích. Po individuální fyzioterapii došlo také ke statisticky významnému ($p < 0{,}001$) zvětšení rozsahu abdukce v čelistním kloubu (z 37,3 mm na 41,3 mm) a ke statisticky významnému ($p < 0{,}001$) snížení intenzity zvukových fenoménů při pohybech dolní čelisti (z původních 100 % na 43 %). Dále jsme prokázali přetrvávání efektu individuální fyzioterapie i další zlepšení po dvou měsících od ukončení terapie u těchto sledovaných charakteristik: intenzity bolesti (p < 0,001), rozsahu pohybu (p < 0,003) a zvukových fenoménů (p < 0,001).

Klíčová slova: temporomandibulární kloub, temporomandibulární porucha, individuální fyzioterapie.

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VALIDITY AND RELIABILITY OF "STEP COUNT" FUNCTION OF THE ACTITRAINER ACTIVITY MONITOR UNDER CONTROLLED CONDITIONS

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When assessing human physical activity, numerous objective measuring devices, such as accelerometers, pedometers, heart rate monitors, etc. are involved. The ActiTrainer is a new multifunctional monitoring tool putting all these functions together. The main purpose of this study was to realize standardizing measures of the pedometer ("step count") function of the ActiTrainer under controlled conditions of walking and running and to contribute to the verification of the potentials of this device for physical activity assessment. Performance of the ActiTrainer as a step counter was evaluated against the actual number of steps taken during those two stages of locomotion. Reliability was estimated by: 1) comparison of two ActiTrainer units worn simultaneously on the right and left hip, and 2) comparison of the ActiTrainer with the previously verified Yamax Digiwalker SW-700 pedometer. The sample consisted of 20 volunteer subjects. All subjects covered a distance of 1 kilometer on the hard surface of a 400 meter long athletic oval in two stages (walking and running), while keeping a prescribed pace of locomotion. Each subject wore four devices (one ActiTrainer and Yamax unit on the right and on the left hip). When detecting steps under given controlled conditions, accuracy of the ActiTrainer was very high. Values of Pearson's *r* expressing the relationship between actual and device measured steps ranged from 0.96 to 0.97. Marginal counts of steps measured by ActiTrainer did not exceed a difference of 0.3% from the actual steps taken. Also inter-instrumental (right vs. the left side) and equivalence (ActiTrainer vs. Yamax) correlations were favorably strong. As a step counter, the ActiTrainer seems to be a promisingly accurate monitoring tool.

Keywords: Physical activity monitoring, walking, running, pedometer, accuracy.

INTRODUCTION

An accurate assessment of physical activity is an important means for a variety of applications in public health research. The physical activity assessment in various subgroups of the population requires a choice of adequate and sufficiently valid methods of measurement. Contemporary methodology of the physical activity assessment offers tens of objective and subjective methods intended for laboratory and field monitoring, particularly direct and indirect calorimetry, doubly labeled water (DLW), motion sensors (e. g. accelerometers, pedometers), heart rate monitors, direct observation or a variety of questionnaire and log techniques (Montoye, Kemper, Saris, & Washburn, 1996). The selection of a concrete method depends on the objectives of a research project, the size and characteristics of the sample (age, sex, health status, employment, level of fitness), budget estimates of research, etc.

Continuously, in addition to standardized methods used on a long term basis, new technologies intended for both the research field and individual use are being developed. The ActiTrainer Activity Monitor is one of the newest multifunctional tools, which is presented as being "revolutionary" (www.actitrainer.com). The term "revolutionary" is grounded in the fact that the ActiTrainer is the first and only 24 hour monitoring tool available that accurately measures (The ActiGraph, 2007): calories burned, heart rate (together with the Polar Wearlink® heart monitoring strap), intensity level, pace/distance traveled, step count, nighttime awakenings and sleep efficiency. Primarily, the ActiTrainer technology is based on the ActiGraph accelerometer with additional functions.

The ActiGraph accelerometer (formerly manufactured under the makes CSA and MTI) belongs among devices often involved in validation studies under laboratory and free living conditions in various groups of adults (Ainsworth, Bassett et al., 2000; Bassett et al., 2000; Brage, Wedderkopp, Franks, Andersen, & Froberg, 2003; Hendelman, Miller, Baggett, Debold, & Freedson, 2000; King, Torres, Potter, Brooks, & Coleman, 2004; Melanson & Freedson, 1995; Metcalf, Curnow, Evans, Voss, & Wilkin, 2002; Nichols, Morgan, Chabot, Sallis, & Calfas, 2000; Sirard, Melanson, Li, & Freedson, 2000; Strath, Bassett, & Swartz, 2003; Swartz et al., 2000; Welk, Blair, Wood, Jones, & Thompson, 2000; Welk, Schnaben, & Morrow, 2004) and children/adolescents

(Brage, Wedderkopp, Andersen, & Froberg, 2003; de Vries, Bakker, Hopman-Rock, Hirasing, & van Mechelen, 2006; Eisenmann et al., 2004; Ekelund et al., 2001; Kelly et al., 2004; Kelly, Reilly, Grant, & Paton, 2004; Puyau, Adolph, Vohra, & Butte, 2002; Trost et al., 1998; van Coevering et al., 2005) or tested mechanically (Brage S., Brage N., Wedderkopp, & Froberg, 2003). A recent independent evaluation of accelerometry data has shown the ActiGraph to be the most accurate commercially available device to assess daily physical activity (Plasqui & Westerterp, 2007). The study compared data collected by eight commonly used accelerometers against the DLW technique, which is considered to be the most accurate measure of energy expenditure under free living conditions. The study concluded that the ActiGraph was the only commercially available monitor that showed positive correlation with the DLW derived results.

This study is oriented to how accurate the ActiTrainer, an ActiGraph derivative, would be as a step counter. The function of a pedometer was chosen because of 1) an increase in "research interest" in pedometers, 2) the fact that walking prevails in habitual physical activity and 3) the relatively easy availability of standardized means for evaluation.

OBJECTIVES AND RESEARCH QUESTIONS

The main purpose of this study was to realize standardizing measures of the pedometer ("step count") function of the multifunctional monitoring device ActiTrainer under controlled conditions of walking and running and to contribute to the verification of the potential of this device for physical activity assessment.

The secondary purposes were: 1) to determine the validity of the pedometer function of the ActiTrainer device under controlled conditions against a criterion of an actual number of steps; 2) to determine the interinstrumental reliability of the ActiTrainer device under controlled conditions via comparison of two devices worn simultaneously on the right and left hips; 3) to compare the ActiTrainer device with the previously verified Yamax Digiwalker SW-700 pedometer under controlled conditions. Moreover, the following research questions were specified:

1) What are the differences between the actual number of steps and the number of steps measured by the ActiTrainer and Yamax devices?
2) When measuring the number of steps, is there any dependence of the accuracy of the measures on the placements of the ActiTrainer and Yamax devices on the right or left side of someone's body?
3) To what extent does the measured number of steps differ between the ActiTrainer and Yamax devices?

SAMPLE AND METHODS

The sample involved in these verification measures consisted of 20 volunteer subjects (10 men and 10 women), students of the Faculty of Physical Culture, Palacký University in Olomouc (TABLE 1). None of them would be classifiable as obese.

Performance of the ActiTrainer as a step counter was evaluated against an actual number of steps taken during a test containing two stages of locomotion (walking and running). Reliability was estimated by: 1) comparison of two ActiTrainer units worn simultaneously on the right and left hips (interinstrumental reliability), and 2) comparison of the ActiTrainer with the previously verified Yamax (new lifestyles) Digiwalker SW-700 pedometer (equivalence). The Yamax pedometer is acceptable as a criterion pedometer (Schneider, Crouter, & Bassett, 2004). This validity/reliability project was based on a validation scheme indicating acceptable criterion standards by Sirard and Pate (2001) indicating acceptable criterion standards.

Internal mechanisms of those involved devices differ considerably. The ActiTrainer utilizes a two axis solid state accelerometer to interpret movement of the body to which it is attached. Special algorithms are applied which accurately determine the amount of energy (calories) expended, steps taken, distance traveled and walking or running speed of the user. The data collected while the ActiTrainer is worn is logged in the internal memory of the device, which can store approximately 64 days of consecutive data before being cleared (The ActiGraph, 2007). The Yamax pedometer is a relatively simple electronic device used to estimate a distance walked or the number of steps taken over a period of time. Its technology uses a spring-suspended horizontal lever arm that moves up and down in response to the hip's vertical accelerations. This movement opens and closes an electrical circuit; the lever arm makes electrical contact (metal on metal contact) and a step is registered (Schneider, Crouter, Lukajic, & Bassett, 2003). Pedometers of this category do not have any capabilities for data storage.

ActiTrainer (10) and 20 Yamax (20) units were used in this study, interchanged systematically among subjects. Each subject wore four motion sensors (two of either brands) placed bilaterally on the right and left hips.

All subjects covered a distance of 1 kilometer on the hard surface of a 400 meter long athletic oval in each of the two stages (walking/running), while keeping a prescribed pace of locomotion. The recommended duration ranges were 10:00–12:30 min. for walking (corresponding to a speed of 4.8–6.0 kilometers per hour; with an approximate intensity of ca. 3.5 METs) and 5:25–6:40 min. for running (at a speed of 9.0–11.0 kilometers per hour;

with ca. 10 METs). Those intensity levels were estimated according to the "Compendium of Physical Activities" (Ainsworth, Haskell et al., 2000). The actual number of steps taken was registered by a digital counter. The study took place in May, 2008. All measures were realized under mild climactic conditions.

All analyses were performed using Statistica 6.0 software. For all analyses, an alpha (p) of 0.05 was used to denote statistical significance. A percentage difference score was computed and compared with zero. Difference scores of zero would indicate that there was no difference between the actual number of steps and the device – measured number of steps. Positive difference scores represent overestimations and negative scores represent underestimations. Repeated ANOVA measures were used to determine whether there was a significant difference between the mean difference scores of all performed measures (i. e. the actual number of steps, two ActiTrainer units and two Yamax units). A Tukey post hoc test was used to determine eventual differences between single measures. Pearson's product moment correlations were used to estimate validity and reliability scores. Although there is no firm standard by which to evaluate a reliability estimate, it is generally recognized that a reliability estimate needs to be above 0.70 and a validity estimate needs to be above 0.60 to be at an acceptable level (Odom & Morrow, 2006).

RESULTS

TABLE 2 displays the means and standard deviations of actual and device measured steps during the walking stage. There were no significant differences between actual steps taken by male and female subjects [$F\,(1,\,18) = 3.61$ ($p = 0.074$)], although men realized a lower number of steps than women owing to greater stride length. The actual number of steps was slightly overestimated by both types of monitors. However, mean difference scores of all the performed measures in the whole sample showed no significance [$F_{repeated\ measures} = 0.17$; $p = 0.951$].

TABLE 3 shows accordant data for the running stage. While the ActiTrainer monitors tended to underestimate the actual number of steps, the Yamax pedometers continued to overestimate them as during the walking stage. However, the under/overestimations are presumed to be inconsiderable. Again, the actual number of steps did not differ statistically between genders [$F\,(1,\,18) = 1.23$ ($p = 0.282$)]. Similarly, no statistical significance was found between all the performed measures [$F_{repeated\ measures} = 0.01$; $p = 0.999$].

TABLE 4 and 5 present correlation coefficients indicating a very strong degree of agreement between the device measured and the actual number of steps. All the whole sample coefficients exceeded .90 levels, independently of the type of locomotion (walking or running) in cases of both ActiTrainer and Yamax devices.

Inter-instrumental reliability is estimated as a degree of agreement between two devices worn on the right and left hip of the body (TABLE 6). Evidently, those correlations are close to absolute values ($r = 1.00$) in both types of the verified motion sensors. The highest difference scores between the right and left side as performed by the ActiTrainer units in one subject were two steps (walking) or seven steps (running), respectively. Similarly, not even the accuracy of the Yamax pedometers is dependent on the side on which the device is worn.

TABLE 7 and 8 display a very strong consistency of the ActiTrainer and Yamax step counting data. These two types of monitoring tools were almost absolutely correlated, particularly in the running stage.

TABLE 1
Summary characteristics of the sample (M ± SD)

Variable	All subjects (n = 20)	Men (n = 10)	Women (n = 10)
Calendar age [years]	24.00 ± 3.91	24.30 ± 4.47	23.70 ± 3.47
Body weight [kg]	72.85 ± 10.44	80.80 ± 8.09	64.90 ± 4.93
Body height [cm]	177.60 ± 6.50	182.40 ± 4.74	172.80 ± 3.94
BMI [$kg \cdot m^{-2}$]	23.00 ± 2.15	24.29 ± 2.06	21.71 ± 1.34

Legend: M – mean, SD – standard deviation.

TABLE 2
Device measured number of steps (M ± SD) with indication of mean differences (percentage and direction) from actual steps (walking)

Measurement	**All subjects (n = 20)**	**Men (n = 10)**	**Women (n = 10)**
Actual steps	1244.55 ± 70.68	1216.40 ± 75.96	1272.70 ± 54.92
ActiTrainer (right)	1246.75 ± 73.74 +0.18%	1217.80 ± 69.68 +0.12%	1275.70 ± 69.00 +0.24%
ActiTrainer (left)	1247.00 ± 73.55 +0.20%	1218.40 ± 69.62 +0.16%	1275.60 ± 68.97 +0.23%
Yamax (right)	1253.45 ± 75.76 +0.72%	1223.30 ± 73.73 +0.57%	1283.60 ± 68.26 +0.86%
Yamax (left)	1261.25 ± 72.16 +1.34%	1226.70 ± 65.31 +0.85%	1295.80 ± 63.83 +1.82%

Legend: M – mean, SD – standard deviation.

TABLE 3
Device measured number of steps (M ± SD) with indication of mean differences (percentage and direction) from actual steps (running)

Measurement	**All subjects (n = 20)**	**Men (n = 10)**	**Women (n = 10)**
Actual steps	907.00 ± 73.84	892.70 ± 93.44	922.89 ± 43.64
ActiTrainer (right)	905.42 ± 73.78 −0.17%	892.40 ± 95.27 −0.03%	919.89 ± 39.97 −0.33%
ActiTrainer (left)	905.68 ± 74.16 −0.15%	892.20 ± 95.26 −0.06%	920.67 ± 41.05 −0.24%
Yamax (right)	908.00 ± 73.94 +0.11%	894.40 ± 95.04 +0.19%	923.11 ± 40.62 +0.02%
Yamax (left)	908.37 ± 73.96 +0.15 %	894.50 ± 95.10 +0.20%	923.78 ± 40.33 +0.10%

Legend: M – mean, SD – standard deviation.

TABLE 4
Values of correlation coefficients with *p* values for comparison of the device measured and actual number of steps (walking)

Comparison	**All subjects (n = 20)**	**Men (n = 10)**	**Women (n = 10)**
Actual steps vs. ActiTrainer R	r_p = .979; p = 0.000	r_p = .992; p = 0.000	r_p = .979; p = 0.000
Actual steps vs. ActiTrainer L	r_p = .979; p = 0.000	r_p = .992; p = 0.000	r_p = .981; p = 0.000
Actual steps vs. Yamax R	r_p = .975; p = 0.000	r_p = .984; p = 0.000	r_p = .967; p = 0.000
Actual steps vs. Yamax L	r_p = .904; p = 0.000	r_p = .967; p = 0.000	r_p = .790; p = 0.007

Legend: r_p – Pearson's correlation coefficient, p – level of statistical significance, R – right side, L – left side.

TABLE 5
Values of correlation coefficients with p values for comparison of the device measured and actual number of steps (running)

Comparison	All subjects (n = 20)	Men (n = 10)	Women (n = 10)
Actual steps vs. ActiTrainer R	r_p = .961; p = 0.000	r_p = .959; p = 0.000	r_p = .966; p = 0.000
Actual steps vs. ActiTrainer L	r_p = .963; p = 0.000	r_p = .961; p = 0.000	r_p = .968; p = 0.000
Actual steps vs. Yamax R	r_p = .960; p = 0.000	r_p = .958; p = 0.000	r_p = .964; p = 0.000
Actual steps vs. Yamax L	r_p = .962; p = 0.000	r_p = .960; p = 0.000	r_p = .967; p = 0.000

Legend: r_p – Pearson's correlation coefficient, p – level of statistical significance, R – right side, L – left side.

TABLE 6
Values of correlation coefficients with p values for inter-instrumental comparison of the number of steps measured by devices worn on right and left hip

Comparison	All subjects (n = 20)	Men (n = 10)	Women (n = 10)
R vs. L ActiTrainer (walking)	r_p = .999; p = 0.000	r_p = .999; p = 0.000	r_p = .999; p = 0.000
R vs. L ActiTrainer (running)	r_p = .999; p =0.000	r_p = .999; p = 0.000	r_p = .998; p = 0.000
R vs. L Yamax (walking)	r_p = .926; p = 0.000	r_p = .970; p = 0.000	r_p = .849; p = 0.002
R vs. L Yamax (running)	r_p = .999; p = 0.000	r_p = .999; p = 0.000	r_p = .999; p = 0.000

Legend: r_p – Pearson's correlation coefficient, p – level of statistical significance, R – right side, L – left side.

TABLE 7
Values of correlation coefficients with p values for comparison of the ActiTrainer and Yamax devices (walking)

Comparison	All subjects (n = 20)	Men (n = 10)	Women (n = 10)
ActiTrainer R vs. Yamax R	r_p = .991; p = 0.000	r_p = .996; p = 0.000	r_p = .982; p = 0.000
ActiTrainer R vs. Yamax L	r_p = .925; p = 0.000	r_p = .972; p = 0.000	r_p = .851; p = 0.002
ActiTrainer L vs. Yamax R	r_p = .990; p = 0.000	r_p = .996; p = 0.000	r_p = .981; p = 0.000
ActiTrainer L vs. Yamax L	r_p = .924; p = 0.000	r_p = .971; p = 0.000	r_p = .851; p = 0.002

Legend: r_p – Pearson's correlation coefficient, p – level of statistical significance, R – right side, L – left side.

TABLE 8
Values of correlation coefficients with p values for comparison of the ActiTrainer and Yamax devices (running)

Comparison	All subjects (n = 20)	Men (n = 10)	Women (n = 10)
ActiTrainer R vs. Yamax R	r_p = .997; p = 0.000	r_p = .999; p = 0.000	r_p = .999; p = 0.000
ActiTrainer R vs. Yamax L	r_p = .998; p = 0.000	r_p = .999; p = 0.000	r_p = .998; p = 0.000
ActiTrainer L vs. Yamax R	r_p = .999; p = 0.000	r_p = .999; p = 0.000	r_p = .999; p = 0.000
ActiTrainer L vs. Yamax L	r_p = .998; p = 0.000	r_p = .999; p = 0.000	r_p = .998; p = 0.000

Legend: r_p – Pearson's correlation coefficient, p – level of statistical significance, R – right side, L – left side.

DISCUSSION

When detecting steps under given controlled conditions, the accuracy of the ActiTrainer was very favorable. The values of Pearson's *r*, expressing the relationship between actual- and device-measured steps, ranged from 0.96 to 0.97. As a criterion for pedometer usability, the Japanese industrial standard is often applied (Hatano, 1993). This recommendation has set the maximum permissible error of miscounting steps at 3%, or 3 steps out of 100. Marginal counts of ActiTrainer measured steps did not exceed a difference of 0.3% from the actual steps taken, i.e. a tenth of the recommended standard.

Differences between step counts measured by the ActiTrainer and Yamax (as the criterion pedometer) were only minor. Correlations between these two technically unequal devices tended to be very strong (0.92–0.99). Consistently with these findings, Bennett and Campagna (2002) indicate a strong relationship between the CSA/ActiGraph accelerometer (the above mentioned ActiTrainer fore runner) and the Yamax pedometer ($r = 0.97$) when assessing daily step count activity. Eighty one participants completed selected moderate intensity tasks in a study of Bassett et al. (2000). In these analyses, the ActiGraph and Yamax devices were correlated by $r = 0.803$. Both motion sensors were compared under free living conditions for seven consecutive days in a sample of 52 subjects by Tudor-Locke, Ainsworth, Thompson, and Matthews (2002). There was a strong relationship between all ActiGraph output and pedometer output (r = 0.74–0.86). Invariably, Yamax pedometers are the most accurate step counters in both controlled and free living settings (Bassett, 2000; Crouter, Schneider, Karabulut, & Bassett, 2003; Le Masurier, Lee, & Tudor-Locke, 2004; Schneider, Crouter, & Bassett, 2004; Schneider, Crouter, Lukajic, & Bassett, 2003; Vincent & Sidman, 2003; Welk et al., 2000). Thus, a similar accuracy of detecting steps under various conditions can be expected also with the ActiTrainer. However, further analyses in this field are needed.

In this study, the validity and reliability of the ActiTrainer for counting steps was verified using two ways of locomotion (i.e. walking and running) with no evident differences in accuracy between them found. Nevertheless, many studies (Bassett, 2000; Beets, Patton, & Edwards, 2005; Brisson & Tudor-Locke, 2004; Karabulut, Crouter, & Bassett, 2005; Melanson et al., 2004; Rowlands, Stone, & Eston, 2007) suggest that motion sensors are less accurate at very slow and very high speeds (according to lower sensitivity of devices at both slow and fast frequencies of movements). On the other hand, the too high sensitivity of a device can lead to erroneous detections of nonsteps (Le Masurier & Tudor-Locke, 2003).

Expectedly, the inter-instrumental correlations of ActiTrainer devices worn simultaneously on the right and left hips were very close to absolute values (0.99–1.00). Yngve, Nilsson, Sjöström, and Ekelund (2003) confirm, that the placement of the monitor does not influence the interpretation of the data.

Pedometers belong among the most popular motion sensors for researchers and for individual use because of their relative accuracy, low cost and acceptable ("user friendly") interpretation of data (i.e. steps), easily comparable with public health recommendations for ambulatory activity (e.g. Tudor-Locke & Bassett, 2004). Nevertheless, the electronic pedometers have limitations as research tools, including their inability to provide information related to nonambulatory activity (i.e., cycling, weight training, and swimming) or underestimating the cost of most other types of "lifestyle" activities, especially those involving arm activity, pushing or carrying objects, walking uphill, or stair climbing (Schneider, Crouter, & Bassett, 2004; Schneider, Crouter, Lukajic, & Bassett, 2003). Epidemiological pedometer data should thus be interpreted with these limitations in mind. On the other hand, although the ActiTrainer does not belong in the low cost category of monitoring tools, its advantages arise from the fact that it engages also a heart rate monitoring feature for precision in obtaining data (www.actitrainer.com).

In follow up analyses, verification of the other features of the multifunctional ActiTrainer device, including the determination of its validity in field settings when assessing physical activity variables in various groups of population, is assumed.

CONCLUSIONS

When detecting steps under given controlled conditions, the accuracy of the ActiTrainer was very high. Values of correlations expressing relationships between actual and device measured steps ranged from .96 to .97. Marginal counts of the steps measured by the ActiTrainer did not exceed a difference of 0.3% from the actual steps taken. Also, the inter-instrumental (right vs. left side) and equivalence (ActiTrainer vs. Yamax) correlations were favorably strong. As a step counter, the ActiTrainer seems to be a promisingly accurate monitoring tool. Verification of the other features of the multifunctional ActiTrainer device, including determination of its validity in field settings when assessing physical activity variables in various groups of population, is assumed.

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VALIDITA A RELIABILITA FUNKCE „MĚŘENÍ POČTU KROKŮ" U PŘÍSTROJE ACTITRAINER V KONTROLOVANÝCH PODMÍNKÁCH

(Souhrn anglického textu)

Při výzkumu v oblasti pohybové aktivity je využíváno množství objektivních monitorovacích přístrojů, jako jsou akcelerometry, pedometry, monitory srdeční frekvence apod. ActiTrainer je novým multifunkčním monitorovacím přístrojem, který tyto funkce spojuje. Hlavním cílem této studie bylo realizovat standardizační analýzu funkce „měření počtu kroků" u přístroje ActiTrainer v kontrolovaných podmínkách chůze a běhu a přispět tak k ověření možností tohoto přístroje pro výzkum pohybové aktivity. Validita detekce kroků u přístroje ActiTrainer byla stanovena proti kritériu skutečného počtu kroků vykonaného během kontrolovaného testu. Reliabilitu určilo 1) porovnání dat ze dvou přístrojů ActiTrainer nošených simultánně na pravém a levém boku a 2) porovnání přístroje ActiTrainer s již dříve ověřeným pedometrem Yamax Digiwalker SW-700. Výzkumný soubor tvořilo 20 osob, jejichž úkolem bylo překonat předepsaným tempem dvakrát (chůzí a během) vzdálenost jednoho kilometru na 400 m atletickém ovále s umělým povrchem. Každé z osob byly nasazeny celkem čtyři přístroje (po jednom přístroji ActiGraph a Yamax na každé straně). Při detekci kroků v daných kontrolovaných podmínkách byla přesnost přístroje ActiTrainer velmi vysoká. Hodnoty korelačních koeficientů vyjadřujících vztah mezi skutečným a naměřeným počtem kroků se pohybovaly mezi 0,96 a 0,97, přičemž odpovídající odchylka od skutečného počtu kroků nečinila více než 0,3 %. Velmi vysoké byly korelační koeficienty i při porovnání hodnot počtu kroků naměřených dvěma přístroji ActiTrainer nošenými jednou osobou na pravém a levém boku, podobně jako při vzájemném srovnání přístrojů ActiTrainer a Yamax. V oblasti monitoringu chodecké aktivity se přístroj ActiTrainer jeví jako velice slibný.

Klíčová slova: monitoring pohybové aktivity, chůze, běh, krokoměr, přesnost.

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THE USE OF FORMAL CONCEPT ANALYSIS IN EVALUATION OF THE RELATIONSHIP BETWEEN THE ENVIRONMENT AND PHYSICAL ACTIVITY OF THE RESIDENTS IN CZECH REGIONAL CITIES

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Current trends in research promote an interdisciplinary approach to the description of real conditions in the most precise way, which means a variety of variables enter into analysis. Therefore, accurate statistical analysis must be carried out. The aim of the study was to identify variables that indicate the presence of an environment conducive to physical activity in neighborhoods where a random sample of 15–65 year old inhabitants living in regional towns was taken (Brno, České Budějovice, Hradec Králové, Liberec, Olomouc, Ostrava, Plzeň and Ústí nad Labem) using the method of Formal Concept Analysis (FCA).

Environmental characteristics of neighborhoods and demographic data of respondents (384 females and 278 males) were obtained using the ANEWS questionnaire in Spring and Autumn of 2007. Respondents were asked to wear the pedometer Yamax SW 701 at the same time, to objectively monitor their week long physical activity (PA). Formal concept analysis is a method of exploratory data analysis that aims at the extraction of natural clusters from object attribute data tables.

An increase in the number of steps per day is significantly (≥10%) influenced by the following neighborhood characteristics – streets highly suitable for walking, a pleasant neighborhood, access to facilities and services and participation in an organized PA (≥2 times a week). In males increased steps were further influenced by the number of nonsmokers in their category and the number of respondents who were not obese.

An environment conducive to physical activity in neighborhoods of the Czech regional towns (according to the number of steps per day) can be described as having accessible facilities and services, an absence of cul-de-sacs, with walkable streets that are clean and having trees along the roads.

Keywords: ANEWS questionnaire, walking, number of steps, formal concept, formal concept lattice, characteristic attribute.

INTRODUCTION

To obtain the best description of phenomena in their natural environment requires identifying the number of objective and subjective variables, both quantitative and qualitative. Among the phenomena that kinanthropology aims to describe is an environment conducive to physical activity in regional cities, the populations of which accounts for 24.5% of the Czech Republic's overall population (Český statistický úřad/Czech National Statistics Office, 2007). Everyday walking and other types of physical activity are a proven prevention strategy against civilization diseases and are predictors of longevity and a physically active lifestyle (Miles, 2007). Therefore, when planning, constructing and reconstructing urban areas, aspects associated with walking and cycling should be considered – service accessibility, walkability of streets, the absence of cul-de-sacs, adequate width of sidewalks, barrier free pavements and paths and their safety and cleanness (Frank et al., 2005; Saelens et al., 2003). GIS analyses provide a geographic description of the environment, identify detailed indicators of particular locations and enable us to create models for different uses of the given environment. Such models are, however, only technical and do not have to correspond with the subjective perceptions of the environment by the inhabitants (Leslie et al., 2005).

The subjective descriptions are mediated, e. g., by surveys. An example of a comprehensive survey assessing the environment of cities is the "Neighborhood Environment Walkability Scale" involving a wide scope of questions: D) types of residence in your neighborhood, E) stores and other facilities in your neighborhood, F) access to services, G) streets in my neighborhood, H) places for walking and cycling, I) neighborhood surroundings and J) neighborhood safety. The answers to the questions in the clusters F)–J) are scored as follows: 1 – strongly disagree, 2 – somewhat disagree, 3 – somewhat agree, 4 – strongly agree. In order to obtain the total score for the clusters of questions F) to J), it is recommended to calculate the arithmetic mean of points for individual questions – factor scoring for the Neighborhood Environment Walkability Scale (NEWS), Scoring for the Neighborhood Environment Walkability Scale – Abbreviated (ANEWS), which we do not consider to be appropriate. For example, the arithmetic mean in the interval 2.3 to 2.7 expresses "something between" somewhat disagree and somewhat agree. Moreover, some questions in some clusters are mutually conditioned: H1) there are sidewalks on most of the streets in my neighborhood and H2) sidewalks are separated from the road/traffic in my neighborhood by parked cars. The answer "completely disagree" to question H1) automatically implies the answer "completely disagree" to question H2. Here the condition of the logically correct use of the arithmetic mean is broken. Therefore, we aimed at finding a different way of how to calculate and express the total scores for the particular clusters of questions of the ANEWS questionnaire.

Formal conceptual analysis (FCA) seems a possible means by which to analyze data. FCA is a mathematical method to identify interesting clusters of objects from a matrix of data having the characteristics of the analyzed objects. The matrix of data is called formal context.

The formal context (X, Y, I) involves two sets X and Y and a relation I between the X and Y sets. The element of the X set is called an object and the element of the Y set is called an attribute. xIy or $(x, y) \in I$ is interpreted as "the object x has the attribute (characteristic) y". For the set of objects $A \subseteq X$ we define:
$A^{\uparrow} = \{y \in Y \mid xIy \text{ for all } x \in A\}$ (the set of attributes, which the objects from A have). Similarly, for the set of attributes B, we define: $B^{\downarrow} = \{x \in X \mid xIy \text{ for all } y \in B\}$ (the set of all objects, which have attributes from B).

On the basis of these two operations, we can define the formal concept. The formal concept from the context (X, Y, I) is the pair (A, B), where $A \subseteq X$, $B \subseteq Y$, $A^{\uparrow} = B$ a $B^{\downarrow} = A$. The set A is called the extent and the set B is called the intent of the concept (A, B). B (X, Y, I) is to denote the set of all concepts from the context (X, Y, I). The set B (X, Y, I) forms a cluster according to the basic theorem of conceptual clusters. A partial arrangement of the elements in the cluster can be used to browse the cluster.

The majority of objects in everyday life show multi value characteristics. In a person, such kinds of characteristics are, e. g. age or height. Using classical logic, these characteristics can hardly be described, because we operate with only two values – 1 and 0; expressing true or not true values. Fuzzy logic is a possible means of how to describe such characteristics.

The result is formally fuzzy conceptual analysis. We present a not empty set of objects X and a not empty set of attributes Y. We select a structure L of true values (L is in the form of a complete residual cluster). L provides a suitable scale of true values with their structure. Using L we assess the statement that "object x has the attribute y". We consider a binary fuzzy relation I between X and Y. I (x, y) is interpreted as a level of truthfulness of the fact that object $x \in X$ has the attribute $y \in Y$. Fuzzy context (or L context) is then a triple ⟨X, Y, I⟩. Here we also define representation $^{\uparrow}: L^X \to L^Y$ a $^{\downarrow}: L^Y \to L^X$

$$A^{\uparrow}(y) = \bigwedge_{x \in X} A(x) \to I(x, y)$$

$$B^{\uparrow}(x) = \bigwedge_{y \in Y} B(y) \to I(x, y)$$

Using them we define a fuzzy concept from the context ⟨X, Y, I⟩ which is the pair ⟨A, B⟩, where $A \in L^X$ and $B \in L^Y$ are such that:

$A^{\uparrow} = B$ a $B^{\downarrow} = A$.

We denote B (X, Y, I) a set of all fuzzy concepts from the context (X, Y, I). The set B (X, Y,I) forms a cluster according to the theorem of conceptual clusters.

In Kinanthropology, the method of Formal Conceptual Analysis was first applied in processing the data of physical activity levels in the population of the Czech Republic obtained using the IPAQ questionnaire (Sigmund et al., 2007; 2008).

AIM

The main aim of the study was to identify variables pointing out the physical activity friendliness of the environment and to what extent it was stimulating to activity in a random sample of 15–65 year old inhabitants of the cities of Brno, České Budějovice, Hradec Králové, Liberec, Olomouc, Ostrava, Plzeň and Ústí nad Labem using the method of formal conceptual analysis.

METHODS

Participants

Monitoring of the environment in the cities, demographic characteristics of the inhabitants and their weekly PA was started in the random sample of 1652 inhabitants of the cities of Brno, České Budějovice, Hradec Králové, Liberec, Olomouc, Ostrava, Plzeň and Ústí nad Labem. Out of the total number of participants, 67% (n = 1107) completed the ANEWS questionnaire and weekly physical activity monitoring using Yamax SW 701 pedometers. Of these questionnaires or recording sheets, 13.4% (n = 221) were incomplete or inaccurate. These were not included in the analysis. Out of the total of 886 of fully and correctly completed ANEWS questionnaires and recording sheets, 384 women and 278 men, according to decades of age, were randomly selected for the analysis of the environment in cities and PA levels.

ANEWS questionnaire

The ANEWS questionnaire (Neighborhood Environment Walkability Scale – Abbreviated http://www.ipen-project.org/surveyanews.htm) includes 54 questions on the environment of neighborhoods, which are divided into several categories: D) types of residences in your neighborhood, E) stores, facilities, and other things in your neighborhood, F) access to services, G) streets in my neighborhood, H) places for walking and cycling, I) neighborhood surroundings and J) neighborhood safety. The answers to individual questions in category D) are scored as: 1 – none, 2 – a few, 3 – some, 4 – most, 5 – all. All 23 questions in the E) category can be answered as: 1 – 1–5 min., 2 – 6–10 min., 3 – 11–20 min., 4 – 20–30 min., 5 – ≥ 30 min. and the possibility, "I don't know". Categories F) to J) are scored as follows: 1 – strongly disagree, 2 – somewhat disagree, 3 – somewhat agree, 4 – strongly agree.

Pedometr Yamax SW 701

Along with the ANEWS questionnaire, each participant received a Yamax SW 701 pedometer and a recording sheet to record their individual characteristics (weight, height, age and sex) and daily number of steps. The Yamax Digiwalker SW 200 (Yamax Corporation, Japan) is a light (20 g) and small commercial electronic pedometer that measures vertical oscillations. (Schneider, Crouter, & Bassett, 2004). Yamax uses a spring suspended lever that moves in response to the hip's vertical oscillations. The movement opens and closes an electrical circuit, and each vertical oscillation detected above a critical threshold (0.35 g) is registered as a step taken (Tudor-Locke et al., 2002). Total numbers of counted steps are displayed on a small screen.

In general, pedometers are most accurate in counting steps, less accurate in calculating distance, and least accurate at estimating energy expenditure (Crouter et al., 2003). Because steps are the most direct expression of what the pedometer actually measures, Tudor-Locke and Myers (2001) recommend reporting pedometer data as STEPS.

Formal Conceptual Analysis

From the perspective of FCA the group of respondents can be understood as a set of objects and individual questions as attributes. The respondents answers then, create a binary relation between the set of objects and the attributes. The answers do not have to be necessarily bivalent (yes–no). Multiple value types of answers (age, number of steps,) can appear here. Due to this, a suitable scale needs to be applied to transfer the multiple value type of answers into bivalent forms. The result of this process is a context $\langle X, Y, I \rangle$, where X is the set of objects – respondents, Y is the set of attributes – adjusted answers from the questionnaire and I is the binary relation between X and Y, where $\langle x, y \rangle \in I$ means that respondent x answered yes to question y.

Another adjustment of the questionnaire is based on the idea that some questions are closely related. We consider it more useful to group attributes which resulted from the scaling of the questions into one attribute. Thus we would obtain a more comprehensive view of the questionnaire. This idea made us create so called "aggregate attributes".

Firstly, an expert needs to decide which questions can be grouped into an "aggregate attribute". Then, we replace all the attributes which were formed through scaling with "aggregate attributes" using the following procedure. We calculate the weighted mean of individual attributes and we scale this mean. Formally there is number n of questions in the questionnaire which we want to cluster into the "aggregate attributes". Through scaling of these questions, $\sum_{i=1}^{n} m_i$ of attributes was created, where m_i is the number of attributes which was formed through scaling of the i question. The weighted mean for the object x, is calculated according to the formula:

$$v(x) = \sum_{i=1}^{n} \sigma_i \sum_{j=1}^{m_i} \omega_{ij} I(x, a_{ij}) \, .$$

σ_i is the weight of question i, ω_{ij} is the weight of attribute j which was formed through the scaling of question i, a_{ij} is an attribute which was formed through the scaling of question $i, j \in m_i$ value $v(x) \in <0.1>$. We create 5 aggregate attributes according to these rules:

$<x, \text{very low}> \in I_1$ iff $a(x) \in <0; 0.2>$,
$<x, \text{low}> \in I_1$ iff $a(x) \in (0.2; 0.4>$,
$<x, \text{moderate}> \in I_1$ iff $a(x) \in (0.4; 0.>$,
$<x, \text{high}> \in I_1$ iff $a(x) \in (0.6; 0.8>$,
$<x, \text{very high}> \in I_1$ iff $a(x) \in (0.8; 1>$.

Using these aggregate attributes, we replace all the grouped attributes. In this way, a formal context $\langle X, Y_1, I_1\rangle$ is created, where $Y1$ is the original set of attributes from which we remove all the attributes which we have grouped into aggregate attributes and then we add the aggregate attributes into it: $<x, y> \in I_1$ if y is not an aggregate attribute and for aggregate attributes the above rules are applied.

Example 1

For better understanding we provide an example. There are questions (G1–G3) in the questionnaire which concern streets in my neighborhood. The expert states the values in individual weights: $\sigma G1 = 0.4$, $\sigma G2 = 0.4$ and $\sigma G3 = 0.2$. To all questions, the respondents could choose from among these answers: 1 – strongly disagree, 2 – somewhat disagree, 3 – somewhat agree, 4 – strongly agree. The value of weights ω_{ij} is stated in TABLE 1.

They created 5 "aggregate attributes": street – very low, street – low, street – moderate, street – high, street – very high (the classification of streets depending on their suitability for walking). If respondent x answers the questions this way: G1 – 3, G2 – 1, G3 – 2, will be $v(x) = 0.4 \times 0.75+0.4 \times 0.5+0.2 \times 0.5 = 0.6$ and then $<x, \text{street moderate}> \in I_1$.

Typically, such a formal context contains many objects and a manageable number of attributes. The corresponding concept lattice is too large for an expert to comprehend. In addition, the expert might not be interested in the formal concepts from this concept lattice. Rather, the expert might want to consider aggregates of the individual respondents as objects in the formal context with the aggregates defined by having the same attributes on a set S of attributes specified by an expert, such as those regarding age, sex, etc., with S being a subset of the set Y of all attributes. Attributes from S will be called characteristic attributes. The aggregates we consider are equivalence classes of individual respondents. For respondents $x_1; x_2 \in X$, we put $x_1 \equiv_S x_2$ if and only if $\{x_1\}^{\uparrow} \cap S = \{x_1\}^{\uparrow} \cap S$

Clearly, $\equiv_S$ is an equivalence relationship of X and $x_1 \equiv_S x_2$ means that x_1 and x_2 have the same attributes from S, i. e. are indistinguishable from the attributes of S. We call the classes $[x]_{\equiv_S}$ of $\equiv_S$ aggregate objects and denote, furthermore by X_1 the set of all classes of $\equiv_S$, i. e. $X_1 = X/\equiv_S$, by Y_2, including the set of those attributes from Y_1 not included in S, i. e. $Y_2 = Y_1 - S$. Now, for each class $[x]_{\equiv_S}$ from X_1 and each attribute $y \in Y_2$, we consider the relative frequency of objects in having attribute y and denote it by $I_2([x]_{\equiv_S}, y)$ or simply by $I_2(x, y)$. That is, we put down:

$$I_2(x,y) = \frac{|\{x_1 \in [x]_{\equiv_S} : x_1 \text{ has } y\}|}{|[x]_{\equiv_S}|} .$$

We can consider I_2 a fuzzy relation which will indeed be the case in this study. Namely, we will consider a particular concept lattice associated to $\langle X_1, Y_2, I_2\rangle$, called a lattice of crisply generated fuzzy concepts. For technical reasons, we round up the degrees assigned by I_1 to those from the scale (0; 0.01; ...; 0.99; 1). More details on this method are described in the article (Bělohlávek et al., 2007).

For such a formal fuzzy context $\langle X_1, Y_2, I_2\rangle$ we can calculate a fuzzy conceptual cluster. We base it on the following study Bělohlávek (2002). The conceptual cluster obtained in this way $B(X_1, Y_2, I_2)$ is already suitable for analysis.

RESULTS

The ANEWS questionnaire (Neighborhood Environment Walkability Scale – Abbreviated) includes 54 questions in total. They were answered by 662 respondents. Using the method described above, we created 8 aggregate attributes, from which we created 40 attributes using scaling (8 × 5). Next to these attributes, the context involves other attributes of demographic data: sex

TABLE 1
Weights ω_{ij} from example 1

Questions	Answers			
	1	2	3	4
G1 – absence of cul-de-sac (dead end streets)	0.25	0.5	0.75	1
G2 – short distance between intersections (100 yards or less)	0.25	0.5	0.75	1
G3 – alternative routes for getting from place to place	0.25	0.5	0.75	1

(2 attributes – females, male), BMI – Body Mass Index (4 – lower body weight, normal body weight, overweight and obesity), age (5 – aged 15–29, aged 30–39, aged 40–49, aged 50–59, aged 60–65), smoking (2 – smoker, nonsmoker), driver (2 – has, does not have a driving license), participation in organized physical activity (4 – none, 1 per week, 2–3 per week, more than 3 per week), steps (TABLE 2).

TABLE 2
Scale for value steps

Attribute	Number of steps per week
Steps low	4000–6999
Steps moderate	7000–9999
Steps high	10000–12999
Steps very high	13000–15999

Thus we obtained a formal context which includes 662 objects and 65 attributes. For another adjustment of formal context, aggregate objects are applied. We used sex – male, sex – female and steps (steps – low, steps – moderate, steps – high a steps – very high) as characteristic attributes. The obtained formal fuzzy context includes 8 objects and 59 attributes. Using it, we created a corresponding fuzzy conceptual cluster.

When studying the cluster, we tried to examine what influence the environment (characterized by aggregate attributes) has on the number of steps in respondents. We studied males and females separately. TABLE 3 shows the corresponding concepts for male and TABLE 4 for female. We state only the aggregate attributes at the levels of very high (VH) and high (H). It is also possible to compare the other levels (moderate, low and very low), but we were interested mainly in the positive influence of the environment on steps.

The levels of correspondence in TABLE 3 express a minimal number of respondents in percentage, which show the given attribute. In bold, the most apparent differences between groups of men or women with a low number of steps vs. a high number of steps are presented. Fig. 1 and 2 show variables (attributes) with more than a 10% increase in the groups of men (Fig. 1) and women (Fig. 2) categorized according to the daily number of steps. Fig. 1 and 2 also show the increase of selected individual characteristics of respondents. In both the groups of men and women, we have indentified the highest increase in the attributes F) walking accessibility of services and shops, G) types of streets, and I) neighborhood surroundings; all in the levels high and very high. Out of the individual characteristics of respondents, which are associated with the increasing number of steps per day, are participation in organized physical activity (2 and more times a week) and in the group of men, moreover normal weight and nonsmoking also play a role (Fig. 1 and 2).

The category of questions G) on types of streets in the neighborhood is related to a higher number of steps

TABLE 3
Comparison of concepts of females and males

Intent	level	Gender – male, steps				Gender – female, steps			
		{low}	{moderate}	{high}	{very high}	{low}	{moderate}	{high}	{very high}
D type of resid. apartment	VH	0	0	0	0	0	0	0	0
	H	0.23	0.22	0.20	0.18	0.10	0.19	0.16	0.19
D type of resid. house	VH	0	0.05	0.02	0.05	0	0.03	0.07	0.05
	H	0.46	0.34	0.35	0.42	0.52	0.37	0.37	0.34
E distance of stores and services	VH	0.08	0.04	0.03	0.01	0.10	0.06	0.05	0.03
	H	0.15	0.19	0.18	0.26	0.21	0.39	0.24	0.26
F access to stores and services	VH	**0.40**	**0.52**	**0.54**	**0.53**	**0.42**	**0.48**	**0.51**	**0.57**
	H	0.38	0.37	0.35	0.39	0.47	0.39	0.37	0.30
G type of streets	VH	**0.38**	**0.39**	**0.53**	**0.57**	**0.36**	**0.34**	**0.51**	**0.48**
	H	0.46	0.41	0.31	0.26	0.42	0.43	0.33	0.35
H places for walking/cycling	VH	0.15	0.23	0.15	0.24	0.26	0.29	0.26	0.21
	H	0.76	0.43	0.63	0.45	0.57	0.41	0.48	0.56
I neighborhood surroundings	VH	**0.08**	**0.09**	**0.08**	**0.14**	**0.05**	**0.08**	**0.11**	**0.09**
	H	**0.23**	**0.28**	**0.32**	**0.28**	**0.10**	**0.31**	**0.26**	**0.33**
J neighborhood safety	VH	0.53	0.38	0.49	0.53	0.52	0.44	0.55	0.47
	H	0.46	0.37	0.35	0.39	0.36	0.45	0.34	0.45

(>10000), therefore we focused more on individual questions in this category. The category G) includes the following questions: G1) – the streets in my neighborhood **do not** have many cul-de-sacs (dead end streets). G2) – the distance between intersections in my neighborhood is usually short (less than 100 meters). G3) – there are many alternative routes for getting from place to place in my neighborhood. (I don't have to go the same way every time.) Using FCA, we have expressed in % representation of positive answers (strongly agree) to questions G1) to G3) in groups of men and women. Fig. 3 shows that mainly the absence of cul-de-sacs in the neighborhoods and the possibility to choose alternative routes in getting from place to place support daily physical activity in the inhabitants of the regional cities.

Fig. 1
Variables with the most apparent increase (≥10 %) of representation in groups of men classified according to daily number of steps

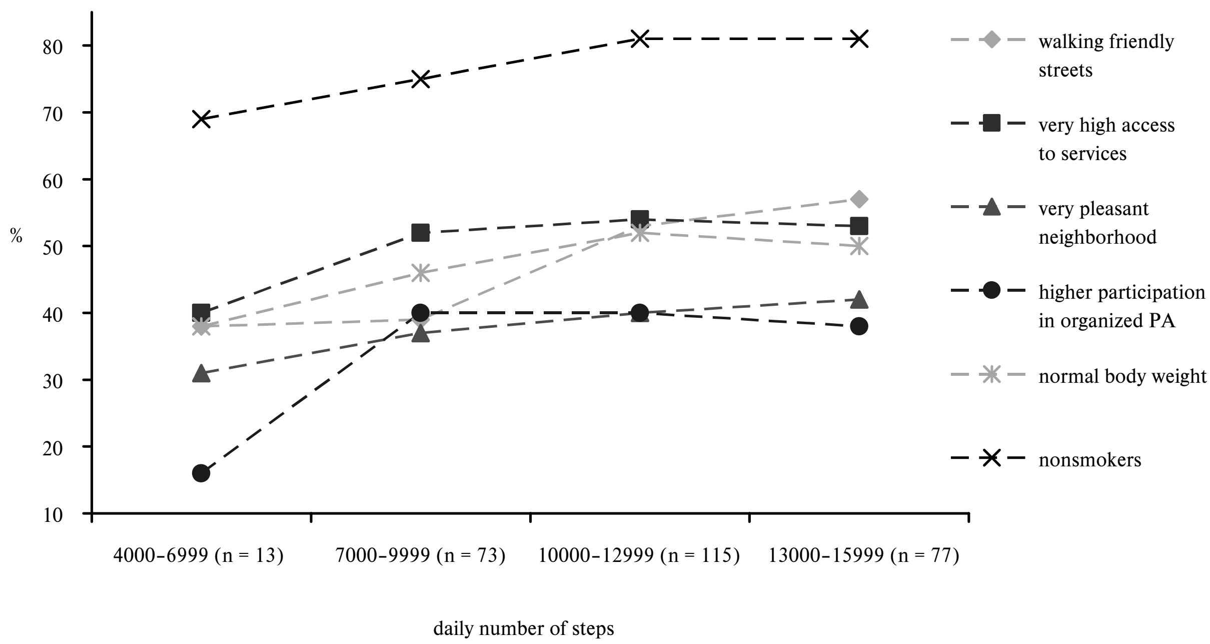


Fig. 2
Variables with the most apparent increase (≥10 %) of representation in groups of women classified according to daily number of steps

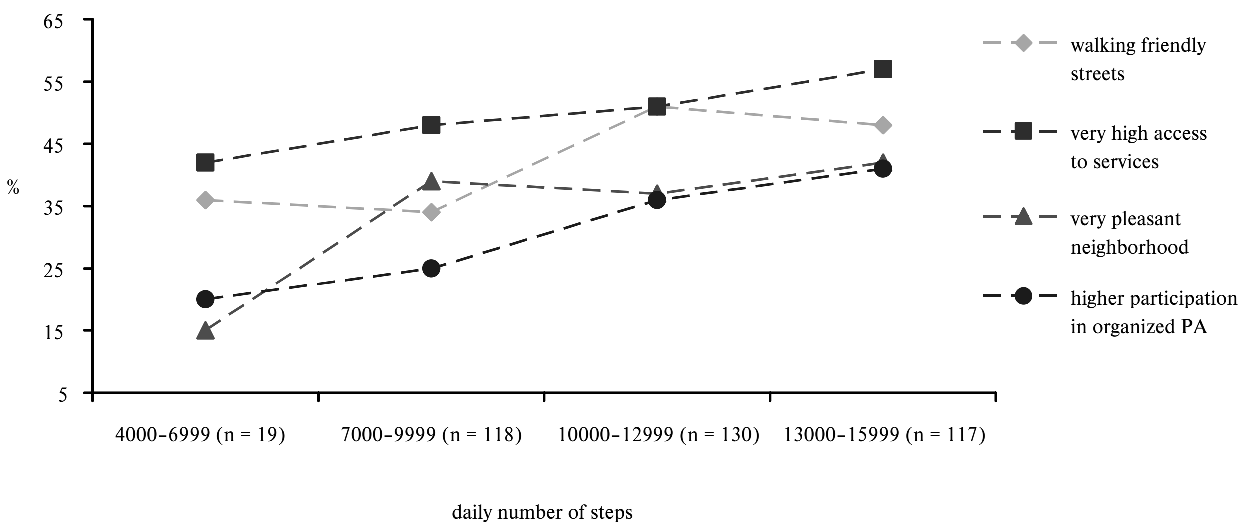
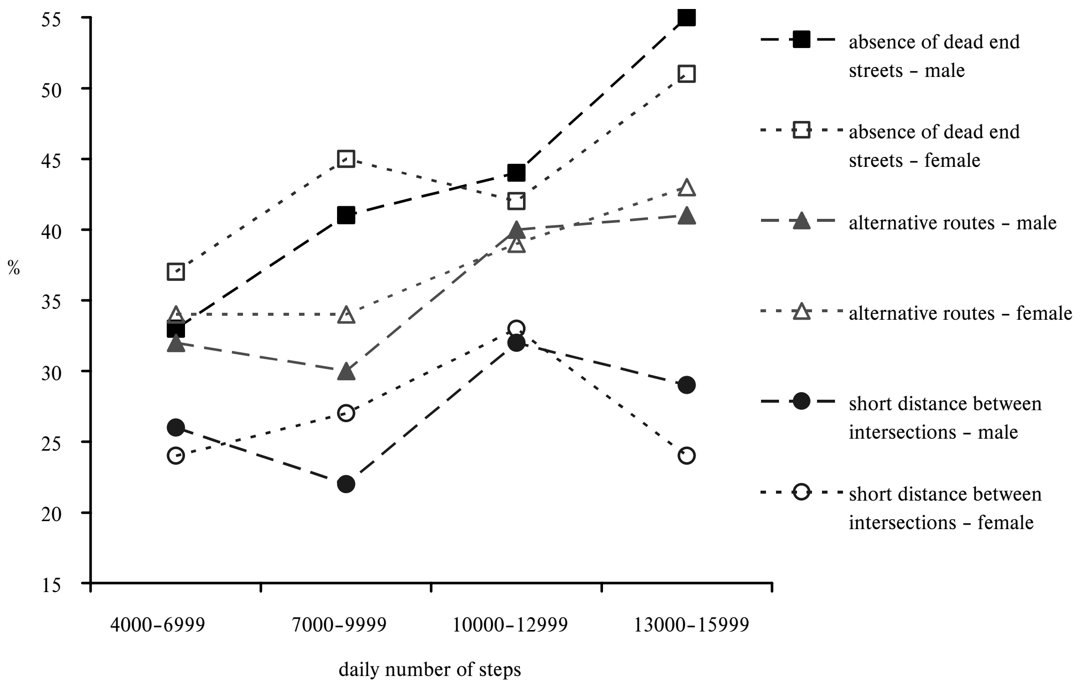


Fig. 3
Types of streets in neighborhoods of men and women according to the daily number of steps



DISCUSSION

The main aim of the study was to identify variables pointing out physical activity friendly and stimulating environments in a random sample of 15–65 year old inhabitants of selected cities in the Czech Republic using the method of Formal Conceptual Analysis. The answers of the respondents in the random sample of the 15–65 year old population to the questions in the ANEWS questionnaire and their physical activity levels provide a sufficient base in order to identify common attributes related to a walking and cycling friendly environment in Czech cities. The tools involved in the Formal Conceptual Analysis ("aggregate attribute", "characteristic attribute", "true value", "weight of the answer") allow more views of the data; especially, in the case of non metric data (nominal and ordinal data) that require non parametric tests. The FCA, however, emphasizes the expert evaluation, e. g. weights, when scoring individual questions in the same category or the choice of the limit values of the intervals of aggregate attributes.

FCA is a mathematical method to identify interesting clusters of objects in a matrix of data which are formed by objects and by the characteristics of the analyzed objects. The matrix of data (formal context) is formed by the objects, attributes (the characteristics of the objects) and by their relations, which state whether a given object has a given attribute. In the classical FCA approach, the relation is bivalent (the object either has the given attribute or not) and is thus formed only from 0 or 1. Yet generally, we work with multi value or continuous characteristics (height, number of steps per day, age, etc.). "Classical logic", operating only with 0 = not true and 1 = true values, can hardly provide sufficient description of these data. In order to describe such characteristics, we apply fuzzy logic.

The procedure of calculating a fuzzy conceptual cluster is very complex (formal context – formal fuzzy context – formal fuzzy conceptual cluster) but it should lead to the most accurate description of phenomena and their interpretation. In our study, we use 101 true values (0; 0.01; ...; 0.99; 1), which we can interpret as the minimal number of respondents in percentage who have a given attribute or a combination of attributes. Mathematical formulation in percentage is comprehensible to a non expert public, too.

Where there is at least a 10% difference in the characteristics of the environment in groups of men and women categorized according to their number of steps per day (Fig. 1–3), this is considered to be logically significant. The choice of the limits was based on the common variability of the answers (±4%) between equivalent forms of the Czech version of the IPAQ questionnaire and the FCA method for its evaluation (Sigmund et al., 2007). Similarly to other studies using the NEWS questionnaire (Leslie et al., 2005; Saelens et al., 2003) and GIS analysis of the environment (Frank et al., 2005), we have confirmed the hypothesis that a walking friendly environment enhances a higher (longer and more frequent) level of walking and other physical activities. A walking friendly environment is represented by street connectivity, the absence of cul-de-sacs, a combination of commercial and residential areas, esthetics (clean streets, trees, etc.) and by safety. Unlike international studies, all the groups of respondents in our study perceived their neighborhood as being safe or very safe regardless of the categories of the number of steps per day. We need to, however, ask whether the perception of highly safe neighborhoods is not already changing, e.g. with the increasing number of cars and traffic which brings ever more noise and air pollution.

The novelty of this study is represented by the joint use of the "objective" measure of physical activity and the "subjective" assessment of the neighborhoods by the inhabitants. Monitoring was carried out during the "walking and cycling friendly periods" of Spring and Autumn over a usual working week. However, the generalization of the results to all Czech cities would be more profound if other large cities such as Prague, Jihlava, Karlovy Vary, Pardubice, and Zlín had been included in the study. Not having the full range of large cities included in the study can be seen as one of the limits of the study.

CONCLUSION

On the use of the Formal Conceptual Analysis

FCA provides useful tools to describe the relationship between physical activity and the environment in neighborhoods from the kinanthropological perspective. There is a strong emphasis on the expert choice of the limit values of the intervals of aggregate attributes or weights assessment when scoring the individual questions.

On the relationship between the environment in cities and physical activity

Based on the results obtained from the ANEWS questionnaire and the number of steps per day, a physical activity friendly/stimulating environment in Czech cities can be described as having good accessibility to services, highly walkable streets (connectivity, cleanness, the absence of cul-de-sacs) and the nice esthetics of neighborhoods. The factor of participation in regular physical activity is closely associated with the availability of services.

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POUŽITÍ FORMÁLNÍ KONCEPTUÁLNÍ ANALÝZY PŘI HODNOCENÍ VZTAHŮ MEZI PROSTŘEDÍM VYBRANÝCH METROPOLÍ ČESKÉ REPUBLIKY A POHYBOVOU AKTIVITOU JEJICH OBYVATEL

(Souhrn anglického textu)

Současným trendem co nejvěrnějšího popisu reálných jevů je interdisciplinární přístup, který s sebou přináší velké množství analyzovaných proměnných. Důraz je proto kladen na přesné statistické zpracování a co nejvýstižnější interpretaci tak velkého množství různorodých dat. Cílem studie je najít proměnné poukazující na pohybově přátelské a stimulující prostředí metropolí u randomizovaného souboru 15–65letých obyvatel Brna, Českých Budějovic, Hradce Králové, Liberce, Olomouce, Ostravy, Plzně a Ústí nad Labem pomocí metody formální konceptuální analýzy (FCA).

Charakteristiky prostředí metropolí a demografické údaje jejich náhodně vybraných obyvatel (384 žen a 278 mužů) byly mapovány dotazníkem ANEWS v průběhu jara a podzimu roku 2007. Současně s aplikací ANEWS dotazníku byla pomocí pedometru Yamax SW 701 monitorována týdenní pohybová aktivita (PA) zúčastněných obyvatel. FCA je matematickou metodou hledání zajímavých shluků objektů z matice dat o vlastnostech analyzovaných objektů.

S rostoucím denním počtem kroků z Yamaxu se u žen i mužů významně zvyšují (≥10 %) následující charakteristiky prostředí – chodecky vysoce příznivé ulice, velmi příjemné okolí bydliště a chůzí dostupné služby a faktor účasti v organizované PA (≥2 krát týdně). U skupiny mužů navíc i procentuální zastoupení nekuřáků a neobézních jedinců. Pohybově přátelské a stimulující prostředí našich metropolí lze, vzhledem k dennímu počtu kroků, charakterizovat blízkou dostupností služeb, absencí slepých ulic, pěší průchodností ulic, jejich čistotou a osázením stromy.

Klíčová slova: ANEWS dotazník, chůze, počet kroků, formální koncept, formální konceptuální svaz, charakteristický atribut.

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PHYSICAL ACTIVITY RECOMMENDATION AND ITS ASSOCIATION WITH DEMOGRAPHIC VARIABLES IN CZECH UNIVERSITY STUDENTS

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Educated people have got better information about the importance of a proper amount of physical activity, but whether Czech university students meet recommendations for physical activity is not clearly known. International Physical Activity Questionnaire – short version, was collected from 2400 university students and analyzed by the logistical regression method. Meeting recommendations for vigorous PA, moderate PA and walking served as independent variables. Czech university students are a sufficiently active social group, more than 85% of them meet physical activity recommendations and the most influential variable is regular participation in PA. Although students practice an adequate amount of PA in total, there should be some promotion of moderate intensity PA and its suitable portion for young adults.

Keywords: IPAQ – short version, university students, vigorous PA, moderate PA, walking.

INTRODUCTION

Physical activity all leisure and non leisure body movement produced by the skeletal muscles and resulting in an increase in energy expenditure and exercising. A form of leisure time physical activity that is planned, structured, and repetitive. Its main objective is to improve or maintain physical fitness (Public Health Agendy of Canada, 2008) is regarded as part of positive health lifestyle practices (Cockerham, 2007) and have a strong effect on the prevention of many chronic diseases, such as coronary artery disease, high blood pressure, diabetes mellitus, obesity, some cancers and various musculoskeletal conditions (Jones, Ainsworth, Croft, Macera, Lloyd, & Yusuf, 1998). Especially inactive women are vulnerable to osteoporosis, decreased muscular strength and endurance, a low level of physical fitness, and various chronic diseases that are associated with a loss of independence in older age (US Department of health and human services, 1996).

The level of time spent in leisure time physical activity participation declines with age and the transition from adolescence to adulthood is the most critical period in one's life course. This transition means changing roles, e. g. leaving school, getting married, entering full time employment, and starting a family (Zick, Smith, Brown, Fan, & Kowaleski-Jones, 2007). The sooner young people finish their education, the faster their participation in PA starts declining because of changing their social roles. People with low educational attainment also manifest low rates for participation in leisure time physical activity. University or college study postpones role change because leaving school may be a key transition. Studying longer means not only obtaining good knowledge about the importance of a healthy life style, including physical activity participation, but also to devoting time with schoolmates to the practice of various kinds of sport discipline. That's why youth stay physically active longer during their university or college studies and might strengthen the habit of physical activity participation and thus form their own lifestyle (Huang, Harris, Lee, Nazir, Born, & Kaur, 2003).

Educated people better understand the significance of participation in different types of physical activities (range of sport disciplines). If their belief in the importance of regular exercise for health becomes stronger a gradual increase in their prevalence of exercise was evident (Steptoe, Wardle, Fuller, Holte, Justo, Sanderman et al., 1997). Socially and economically disadvantaged people, that is, those with a lower level of education, have fewer opportunities to use the different options available in society. They do not have any interest or reason unless they got used to exercising from childhood.

We investigated, in the sample of the Czech population, whether or not Czech university students meet physical activity guidelines (3 × 20 minutes of vigorous PA or 5 × 30 minutes of moderate PA or 5 × 30 minutes of walking in a week) necessary for achieving health benefits (for instance desease prevention). For this purpose we analyzed them using the International Physical Activity Questionnaire where students recalled their physical activity practiced during the past week. A second concern we were interested in was which type of PA (vigorous PA, moderate PA or walking) prevails in students' leisure time. Finally, we studied different variables that may be associated with meeting the PA guidelines for vigorous intensity PA, moderate intensity PA and walking. Among the very commonly mentioned variables (Sallis, Prochaska, & Taylor, 2000) are age and sex. There is enough evidence that young men are more likely to exercise and to engage in frequent physical activity than young women in 21 European countries except for Finland (Steptoe, Wardle, Fuller, Holte, Justo, Sanderman et al., 1997).

METHODS AND MATERIALS

Population studied

From 2002 to 2004 (Spring and Autumn) trained distributors submitted, helped to complete if necessary and collected 30258 International Physical Activity Questionnaires (short version). It was a sample of randomly selected people (aged 15–69 years) from the whole Czech Republic. From this data set we chose young people aged 20–27 years (n = 2719) who study at different universities or colleges in the Czech Republic. The difference between their age and the number of years of education they have completed was 6 or 7 years because at that age children start attending basic school. We were interested in completely filled out questionnaires with all data about PA, demographic questions and additional information so that questionnaires from students where this information were missing we excluded from the further statistical analysis. Of the 319 excluded records (11.73%), 137 were missing information on location, residence, smoking, living status and having a car, a bike or a cottage, whereas 111 students' questionnaires contained implausible data such as more than 7 days of activity per week, in 10 records students did not mention any physical activity in the past week, 3 records had outliers in self reported BMI and in 58 records the sum of PA and sitting did not correspond with a common lifestyle where we regard 8 hours of sleeping time as the norm. After cleaning up IPAQ data according to guidelines for the data processing and analysis of the "International Physical Activity Questionnaire" (IPAQ website) there were 2400 records from university students who were enrolled in school full time to analyze. From the 2002 Autumn survey we gathered for statistical processing 725 questionnaires, from Spring 2003, there were 285 questionnaires, from Spring 2004, there were 669 questionnaires, and from Autumn 2004, there were 721 questionnaires.

Physical activity behavior

Their recalled physical activity during the last 7 days (prior to filling in the form) was recorded using the validated International Physical Activity Questionnaire (short version). The short form of IPAQ is suitable because it is comprised of four generic items – data on vigorous PA, moderate PA and walking were obtained from participants for the number of days per week and the duration (hours per day and minutes per day). Also a question about time spent sitting on a week day was answered. Demographic and additional information contained personal data (age, gender, body mass index based on self reported height and weight), behavioral information (place of residence – flat or house, smoking status, regular participation in organized PA – in the questionnaire is described as participation in physical activity regularly for most of the time in a year – organized by person or institution), and environmental status (size of and location of residence, living status – alone or in a family, having a car or bike).

Definition of meeting PA guidelines

According to existing recommendations, a person who met any of the following three criteria was considered sufficiently physically active:

- 3 or more days of vigorous PA of at least 20 minutes per day during the last week;
- or 5 or more days of moderate PA and/or walking of at least 30 minutes per day during the last week;
- or 5 or more days of any combination of walking, moderate or vigorous PA during the last week, achieving a minimum of at least 600 MET min. per week.

One MET is defined as the energy spent during quiet sitting (equivalent to [4.184 kJ].$kg^{-1}.h^{-1}$). For different types of PA and their intensities, reported weekly minutes spent were multiplied by 6 MET for vigorous PA, by 4 MET for moderate PA and by 3.3 MET for walking. Individual total PA per week in MET was the sum of walking, moderate and vigorous MET minutes week scores.

For our specific conditions, we applied stricter conditions to students and regarded them to be sufficiently physically active if they met the first or second of the above mentioned criteria. University students who performed, for 3 or more days, vigorous PA of at least 20 minutes per day during the last week were considered to have met recommendation for vigorous PA. Students who performed, for 5 or more days, moderate PA, respectively walking of at least 30 minutes per day during the last week, were considered to have met the recommendation for moderate PA, respectively walking.

Statistical procedures

Data from 2400 university students' questionnaires were statistically processed using the SPSS version of the 16.0 SPSS Inc., Chicago, U.S. software. We used logistical regression to find associations between PA recommendations for vigorous intensity PA, moderate intensity PA and walking and other dependent variables. An independent variable was (a) fulfillment of 3 times 20 minutes of vigorous intensity PA per week (0 – no, 1 – yes), (b) fulfillment of 5 times 30 minutes of moderate intensity PA per week, and (c) fulfillment of 5 times 30 minutes of walking per week. As dependent dichotomous variables included into analyses were sex (0 – male, 1 – female), residence (0 – flat, 1 – house), smoking status (0 – nonsmoker, 1 – smoker), having a car (0 – no, 1 – yes), having a bike (0 – no, 1 – yes), and regular participation in PA (0 – no, 1 – yes). Also dependent categorical variables were inserted – age (5 groups), BMI (0 – normal, 1 – underweight, 2 – overweight), location of residence (4 groups) and living status (0 – alone, 1 – in a family, 2 – in a family with children). We calculated odds ratios with their statistical significance and confidential intervals for all dependent variables using the enter method for logistical regression. Cross tabulations were used to express the percentage of students who successfully met PA guidelines in each category.

RESULTS

A description of our data set is presented in TABLE 1. Data from 2400 university or college students of the white/Caucasian race from the Czech Republic (age 24.86 ± 1.52 years; self reported body weight 67.29 ± 12.24 kg; self reported body height 174.33 ± 9.28 cm) were analyzed. Czech university students are very active because 85.38% of them (n = 2049) met guidelines for PA and only 14.62% (n = 351) did not.

The mean time spent in sitting in university students is 400 minutes per day which is more than 6 hours per day and more than 46 hours per week. If we take into account this cut off point (sitting more than 6 hours per day), 51.04% of students (n = 1225) tend to sit more than six hours per day. But on the other hand, 83% of these students (n = 1016) met health related recommendation for PA.

From TABLE 1 it is evident that meeting PA guidelines declines with age, after the first year – familiarization with the university study system, 21 year old university students (sophomores) are the most active. Over ninety percent of students who own a bike are more likely to meet PA guidelines than those without a bike. Other determinants influencing meeting PA guidelines are regular participation in organized PA, those who do not participate in organized PA regularly are less likely to meet PA guidelines.

Odds ratios and confidential intervals for different demographic, behavioral, and environmental variables are presented in TABLES 2 and 3.

TABLE 2 shows meeting guidelines for vigorous PA which is less likely to be met by girls, smokers, underweight and overweight students, and students in their last study years. On the other hand, a proper level of vigorous PA is easily met for students owning a bike and regularly participating in organized physical activity. Overall, 43.71% of university students met a vigorous PA guideline, which is surprising, compared to only 19.04% of students who met moderate PA guidelines. The recommendation for walking was met by 75.08% of university students.

The effect of a demographic variable on meeting guidelines for moderate PA and walking by Czech university students is shown in TABLE 3, and is less likely to be met by girls and smokers. Five or more days of moderate PA of at least 30 minutes per day is more likely to met by students regularly participating in organized PA. Fulfillment of meeting guidelines for walking is less likely to be achieved by boys (significantly), students having a car, and living in houses. On the other hand, walking is more likely for students owing a bike, living in villages (less than 1000 inhabitants) and regularly participating in organized PA.

For illustration, Fig. 1 shows the distribution of students according to their PA level. A high PA level means that individuals meet one of two criteria: a) vigorous PA on at least 3 days achieving a minimum total PA of at least 1500 MET minutes/week or b) 7 or more days of any combination of walking, moderate PA or vigorous PA achieving a minimum total physical activity of at least 3000 MET minutes/week. Moderate PA level means that individuals meet one of two criteria: a) 3 or more days of vigorous PA of at least 20 minutes per day or b) 5 or more days of moderate PA and/or walking of at least 30 minutes per day. Those individuals who do not meet criteria for moderate or vigorous PA level are considered to have a "low" PA level.

DISCUSSION

In Czech university students walking prevails (more than 75% of students meet the recommendations) they walk an average of 10 hours per week. It is followed by moderate PA (a mean time of 4.0 hours per week) even though only 19% of students meet moderate PA recommendations, which is similar to the results found in the case of US college students (Centers for Disease Control and Prevention, 1997). The problem is that students exercise for a longer time less than five times per week and thus do not meet PA recommendation even if they have enough moderate PA to enhance their health. This indicates a need for the promotion of the appropriate amount of moderate physical activity for health benefits in university students.

Regarding vigorous PA mean time, for students it is 3.9 hours per week and the recommendation is met by more than 43%. In a Russian survey (Levin, Ainsworth, Kwok, Addy, & Popkin, 1999) Russian youth (6–18 years old) spent, in moderate physical activities, 4.7 hours/week and in vigorous intensity activities 2.1 hours/week. Compared to the study done by Suminski, Petosa, Utter and Zhang (2002) among ethnically diverse college students where 53% of the women and 40.3% of the men did not engage in vigorous PA during the month preceding the study, according to our results Czech university students are sufficiently active and meet the PA recommendation for healthy lifestyle.

One of the definitions of a sedentary person suggests that it is an individual who spends less than 10% of their daily energy expenditure in moderate to vigorous intensity activities (Bernstein, Morabia, & Sloutskis, 1999). Even if our students reported more than 46 hours of sitting per week (including studying, sitting at lectures and at computers) most of these students compensated for their sedentary behavior by an adequate level of physical activity. Thus results show that Czech university students are not sedentary people at all.

Variables which were the most influential in the meeting of the PA recommendations in Czech university students are sex, with more males meeting PA guidelines than females which is more consistently supported also by findings in the age group of adolescents 13–18 years old (Sallis, Prochaska, & Taylor, 2000), and age, for example 21 year old students are more likely to meet PA guidelines thanks to their adaptation to the university lifestyle and their specific time constraints related to their academic schedules (Buckworth & Nigg, 2004). Another variable studied was BMI but our results do not prove that body weight can influence the amount of PA which does not correspond with the study done by Sulemana, Smolensky and Lai (2006). The same percentage of overweight (BMI ≥25) students as students with normal weight (BMI 19–24.9) met health related PA recommendations in our study.

Variables connected with living showed that students who live in a small village (<1000 inhabitants) are more likely to meet PA recommendations and also those who live in a family with children are more physically active. Support from the family was found to be very important to female students and on the other hand support from friends or peers was more powerful for male students (Keating, Guan, Piñero, & Bridges, 2005). Living in a flat (not in a house) is an additional factor related to a sufficient level of PA in university students because we feel that staying in a flat forces young people to go out and more often to practice some sports outside or in fitness centers together with friends or mates. But this factor need to be further investigated as to up to what level it may influence students' decisions.

Analyses done by Kerr, Norman, Sallis and Patrick (2008) revealed that the presence of exercise equipment was related to PA in adolescent girls and also in their parents. Such equipment and also a means of transport is a bike as well and its ownership has got a significant impact on the meeting of PA recommendations in Czech university students.

Among the most frequently studied variables, although smoking was indeterminate according to Sallis, Prochaska and Taylor (2000), our results indicate that nonsmokers are more likely to meet PA recommendation than smokers. If we have a close look at the association with meeting the recommendations for vigorous PA, moderate PA, and walking, results show that smoking was inversely significantly related to vigorous PA and moderate PA, but not with regard to walking.

The most influential variable in meeting PA guidelines is regular participation in physical activity. This fact plays the main role for Czech university students and is part of their healthy lifestyle. We did not investigate in which sport discipline they are engaged most often or which is their favorite, so this may be further investigated. Some studies (Leslie, Owen, Salmon, Bauman, Sallis, & Lo, 1999; Reed & Ainsworth, 2007) found that college aged women were less likely than college age men to engage in regular physical activity, but we did not distinguish gender association with regular PA participation. Overall, students are willing to practice some sports in their leisure time if they have the opportunities to exercise which is a consistently positive association with PA (Sallis, Prochaska, & Taylor, 2000).

The short form of the IPAQ "last 7 days recall" in a self administration mode is recommended for national monitoring (Craig et al., 2003). Criterion validity is comparable to most other self report validation studies. It can be used for monitoring population levels of PA among 18 to 65 year old adults under various conditions. But it was administered over three years and only in the Spring and Autumn seasons. That's why it can be a limit of this study due to different weather conditions in those periods of the year and in the students' program (Autumn being at the beginning of the semester in contrast to Spring being at the end of the semester, finishing with exams). It would be interesting to analyze seasonal differences and differences between each year to see whether some trend in physical activities and sitting exists.

Another limitation is that participants were from different universities and with different study programs. Those who study PE as a major or subjects related to sport disciplines may produce above average data about their PA. Despite this fact, age is associated with the level of PA as students reach their 22nd year, PA starts declining for both genders.

TABLE 1
Number of participants according to different variables and their meeting PA guidelines

	Number of participants	Percentage from all participants (n = 2400)	Meeting guidelines for PA	
			n	%
Age (year)				
20	431	17.96	370	85.8
21	747	31.13	659	88.2
22	530	22.08	460	86.8
23	330	13.75	276	83.6
24–27	362	15.08	284	78.5
Gender				
Male	997	41.54	870	87.3
Female	1403	58.46	1179	84.0
BMI				
Normal (19–24.9)	1788	74.50	1528	85.5
Underweight (<19)	282	11.75	239	84.8
Overweight (≥25)	330	13.75	282	85.5
Location				
Metropolis (≥100 000 inh.)	678	28.25	577	85.1
Big city (30 000–100 000 inh.)	502	20.91	431	85.9
Town (1000–29 999 inh.)	880	36.67	747	84.9
Village (less than 1000 inh.)	340	14.17	294	86.5
Living status				
Alone	316	13.17	269	85.1
In a family	1668	69.50	1421	85.2
Family with children	416	17.33	359	86.3
Residence				
Flat	1289	53.71	1108	86.0
House	1111	46.29	941	84.7
Smoking				
No	2026	84.42	1740	85.9
Yes	374	15.58	309	82.6
Having a car				
No	1059	44.13	905	85.5
Yes	1341	55.87	1144	85.3
Having a bike				
No	217	9.04	177	81.6
Yes	2183	90.96	1872	85.8
Regular participation in PA				
No	796	33.17	636	79.9
Yes	1604	66.83	1413	88.1

TABLE 2
Effect of demographic variables on meeting guidelines for vigorous PA (2400 university students)

	Vigorous PA 3 × 20 min./week		
	%	**OR**	**95% CI**
Age (year)			
20	45.2	1.00	Ref.
21	44.2	0.96	0.75–1.24
22	45.8	0.98	0.75–1.29
23	43.6	0.92	0.68–1.26
24–27	37.8	0.73*	0.53–1.00
Gender			
Male	54.2	1.00	Ref.
Female	36.3	0.45**	0.37–0.54
BMI			
Normal	45.7	1.00	Ref.
Underweight	34.0	0.75*	0.57–1.00
Overweight	40.9	0.75*	0.58–0.97
Location			
Metropolis	44.5	1.00	Ref.
Big city	43.8	0.94	0.73–1.20
Town	43.0	0.92	0.73–1.16
Village	43.8	1.05	0.76–1.44
Living status			
Alone	42.7	1.00	Ref.
In a family	44.4	0.91	0.69–1.20
Family with children	41.8	0.75	0.54–1.05
Residence			
Flat	43.7	1.00	Ref.
House	43.7	0.92	0.76–1.13
Smoking			
No	45.5	1.00	Ref.
Yes	34.2	0.68*	0.53–0.87
Having a car			
No	41.2	1.00	Ref.
Yes	45.7	1.11	0.93–1.33
Having a bike			
No	30.4	1.00	Ref.
Yes	45.0	1.54*	1.11–2.14
Participation in PA			
No	23.4	1.00	Ref.
Yes	53.8	3.77**	3.09–4.59

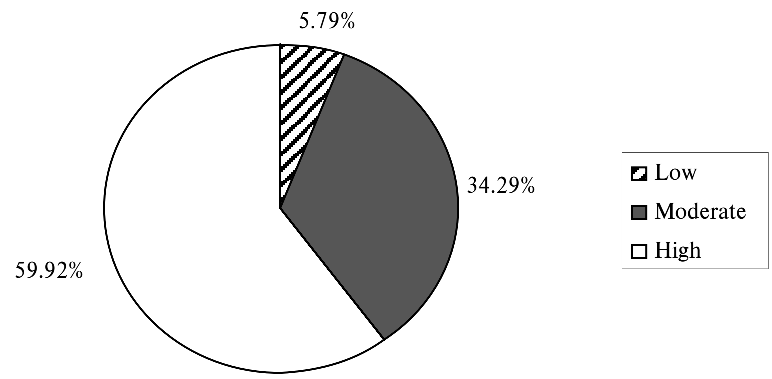
Legend: OR – odds ratio, CI – confidence interval, *$p < .05$, **$p < .001$.

TABLE 3
Effect of demographic variables on meeting guidelines for moderate PA and walking

	Moderate PA 5 × 30 min./week			Walking 5 × 30 min./week		
	%	OR	95% CI	%	OR	95% CI
Age (year)						
20	19.0	1.00	Ref.	76.6	1.00	Ref.
21	20.9	1.14	0.84–1.55	78.8	1.15	0.87–1.54
22	21.1	1.11	0.81–1.54	76.2	0.98	0.72–1.32
23	15.5	0.77	0.52–1.15	72.1	0.81	0.58–1.13
24–27	15.5	0.78	0.53–1.15	66.6	0.63*	0.45–0.87
Gender						
Male	23.0	1.00	Ref.	71.9	1.00	Ref.
Female	16.3	0.61**	0.49–0.75	77.3	1.28*	1.06–1.56
BMI						
Normal	19.6	1.00	Ref.	74.5	1.00	Ref.
Underweight	18.1	1.05	0.76–1.47	78.0	1.16	0.85–1.57
Overweight	17.0	0.79	0.58–1.09	75.8	1.15	0.87–1.52
Location						
Metropolis	18.3	1.00	Ref.	74.5	1.00	Ref.
Big city	19.1	1.04	0.77–1.41	76.3	1.11	0.84–1.46
Town	18.1	0.93	0.70–1.23	73.9	0.98	0.76–1.25
Village	22.9	1.22	0.84–1.76	77.6	1.24	0.87–1.75
Living status						
Alone	19.3	1.00	Ref.	74.4	1.00	Ref.
In a family	18.8	0.81	0.58–1.12	75.0	0.98	0.73–1.32
Family with children	20.0	0.85	0.57–1.26	76.0	1.00	0.70–1.44
Residence						
Flat	17.5	1.00	Ref.	76.0	1.00	Ref.
House	20.9	1.20	0.94–1.52	74.1	0.84	0.68–1.04
Smoking						
No	19.8	1.00	Ref.	75.3	1.00	Ref.
Yes	14.7	0.72*	0.53–0.99	73.8	0.94	0.72–1.21
Having a car						
No	18.7	1.00	Ref.	76.1	1.00	Ref.
Yes	19.3	0.94	0.76–1.17	74.3	0.92	0.75–1.21
Having a bike						
No	14.3	1.00	Ref.	72.8	1.00	Ref.
Yes	19.5	1.23	0.82–1.86	75.3	1.17	0.84–1.63
Participation in PA						
No	13.4	1.00	Ref.	72.6	1.00	Ref.
Yes	21.8	1.70**	1.34–2.17	76.3	1.18	0.97–1.44

Legend: OR – odds ratio, CI – confidence interval, *p < .05, **p < .001.

Fig. 1
Physical activity level in university students (n = 2400)



CONCLUSION

In conclusion, a large percentage of the university students we studied met health related recommendations for PA. This is a very positive result, but recommendations for moderate PA is reached by less than twenty percent of the students. That's the reason why we have to promote the right portion and dose of moderate PA. Further research on university students whose major is not PE or sport disciplines is going to be challenging and necessary.

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VLIV DEMOGRAFICKÝCH UKAZATELŮ NA PLNĚNÍ DOPORUČENÍ PRO POHYBOVOU AKTIVITU U ČESKÝCH VYSOKOŠKOLSKÝCH STUDENTŮ

(Souhrn anglického textu)

Vzdělaní lidé, zejména pak vysokoškolští studenti mají lepší přístup k informacím o důležitosti plnění zdravotních doporučení k pohybové aktivitě a jejich významnosti pro zdravý a aktivní životní styl. Cílem studie je zjistit, zda univerzitní studenti v České republice plní tato doporučení a které demografické ukazatele mají největší vliv na jejich plnění. Pro šetření byl využit mezinárodní dotazník pohybové aktivity (IPAQ) – krátká verze a do logistické regresní analýzy vstoupily údaje z dotazníků od 2400 českých vysokoškolských studentů. Jako nezávislé proměnné jsme zvolili: (a) zda plní doporučení pro intenzivní PA (3 × 20 minut týdně) či ne, (b) zda plní doporučení pro středně zatěžující PA (5 × 30 minut týdně) a (c) zda plní doporučení pro chůzi (5 × 30 minut týdně). Mezi závislé proměnné, které mohou splnění těchto doporučení ovlivňovat, jsme z dotazníku zařadili věk, pohlaví, BMI, místo bydliště, způsob bydlení, způsob života, kouření, vlastnictví auta nebo kola a pravidelnou účast v organizované PA. Z analýzy vyplynulo, že nejvýznamnějším faktorem, který ovlivňuje plnění doporučení PA, jednoznačně patří pravidelná účast v organizované PA. Větší pravděpodobnost, že splní doporučení PA, mají muži, jednadvacetiletí studenti a ti studenti, kteří žijí na vesnici, v rodině, nekouří a vlastní kolo. Více než 85 % českých vysokoškolských studentů splnilo obecná doporučení PA, ale přesto je potřeba posílit propagaci o vhodném množství prováděné středně zatěžující pohybové aktivitě, jelikož příslušné doporučení splnilo pouze 19 % studentů.

Klíčová slova: dotazník IPAQ krátká verze, vysokoškolští studenti, intenzivní PA, středně zatěžující PA, chůze.

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First-line publications

Vašendová, J., Frömel, K., & Sigmund, E. (2001). Reliability of accelerometer Caltrac, pedometer Omron a heart rate monitor Polar in aesthetically oriented girls' physical education classes. In H. Válková & Z. Hanelová (Eds.), *Movement and health*, (pp. 496–500). Olomouc: Univerzita Palackého.

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DANCE AND AEROBIC DANCE IN PHYSICAL EDUCATION LESSONS: THE INFLUENCE OF THE STUDENT'S ROLE ON PHYSICAL ACTIVITY IN GIRLS

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The primary aim of physical education (PE) is to promote lifelong physical activity (PA) and to promote physical literacy in children. During classes children should learn through participation in physical activities and thus physical education lessons should be as active as possible. The aims of this study were firstly to compare physical load in dance and aerobic dance lessons to the recommendation of the minimum of 50% of class time being physically active (USDHHS, 2000) and secondly to identify how the students' role in the educational process affects their engagement in PA. Two hundred and forty one girls completed the full program of dance and aerobic dance lessons. Heart rate telemetry systems were used to measure PA during dance and aerobic dance lessons. Girls spent more than 50% of class time in moderate to vigorous PA in both traditional and progressive dance and aerobic dance lessons. Results from this study suggest that the increased student's role can help to fulfill other PE goals such as responsibility for decision making and creativity along with promoting PA especially in dance and aerobic dance student oriented lessons.

Keywords: Heart rate, traditional and progressive lessons, decision making, creativity.

INTRODUCTION

In a progressively more sedentary society, the role of physical education (PE) in promoting lifelong physical activity (PA) and enhancing children's quality of life should be central to long term health enhancing strategies (Burgeson, Wechsler, Brener, Young, & Spain, 2001). To complete these strategies, PA guidelines and recommendations have been created. The Healthy People 2010 objectives aim to increase the number of schools providing daily physical education as well as the number of PE participants and students who are physically active for at least 50% of lesson lime (USDHHS, 2000). The Health Education Authority (Biddle, Sallis, & Cavill, 1998) recommended accumulation of one hour of PA per day at least twice a week of at least moderate intensity and children's participation in activities that help to develop and maintain muscular-skeletal health. General recommendations for adolescents (Sallis & Patrick, 1994) advocate firstly that all adolescents should be active every day as a part of their daily lifestyles and secondly that adolescents should engage in three or more sessions per week in moderate to vigorous physical activity (MVPA) that lasts 20 min. or more at a time. Several studies reported the important role of PE in delivering health enhancing PA (Fairclough & Stratton, 2005a, 2005b; Levin, McKenzie, Hussey, Kelder, & Lytle, 2001; McKenzie et al., 2006; Stratton, 1996).

Some studies have documented that physical activity drops exponentially during the adolescent period (Allison, Adlaf, Dwyer, Lysy, & Irving, 2007). Furthermore, the review paper by Amstrong and Welsman (2006) revealed that European boys of all ages participate in more PA than European girls, especially considering vigorous PA. Girls also take fewer steps per day and are less active than boys during release or recess time (Tudor-Locke, Lee, Morgan, Beighle, & Pangrazi, 2006). Therefore, there is a strong call for teenage girls' engagement in PE programs that motivate them to adopt lifelong PA habits (Cavill, Biddle, & Sallis, 2001). A range of activities must be offered if girls are to be motivated to take advantage of PA opportunities (Prusak, Treasure, Dars, & Pangrazi, 2004).

Promotion of PA can be fostered through effective curricular and extracurricular programs (Powers, Conway, McKenzie, Sallis, & Marshall, 2002). Furthermore, the teaching process should also be considered. Student oriented PE teaching approaches involve a higher range of decision making, self activity and critical thinking (Bonnette, McBride, & Tolson, 2001; Penney & Chandler, 2000). Moreover, further goals such as developing creative thinking, problem solving, metacognition, social development (Rink, 1998) and self assessment can serve to promote knowledge, understanding and independent learning (Mohnsen, 1997). These valid areas of learning could contrast, however, with meeting PA recommendations and health enhancing strategies. PA varies in different teaching components, e.g content of the lesson, main teaching objective, teaching approach, class size, etc. (Frömel, Vašendová, Stratton, & Pangrazi, 2002; McKenzie, Marshall, Sallis, & Conway, 2000; Stratton, 1996, 1997). PE content thus needs to include activities that are effective in promoting PA along with meeting motor, cognitive, social, spiritual, cultural and moral aims (Sallis & McKenzie, 1991).

In the case of girls, PE activities should also develop their self confidence (Solmon, Lee, Belcher, Harrison, & Wells, 2003). National surveys (Frömel & Bartoszewicz, 1998; Frömel, Formánková, & Sallis, 2002) have provided evidence that dance, aerobic dance, creative and aesthetic activities are highly popular among adolescent girls and furthermore girls' attitudes towards dance show little change between the ages of 11 to 16 (Sanderson, 2001). Dancing is among the top five activities of girls in their leisure time (Harrell, Pearce, Markland, Wilson, Bradley, & McMurray, 2003). Findings presented in literature have shown that dance and aerobic dance can enhance girls' perception of PA. It applies especially to aerobic dance since it is not considered a competitive PA and supports girls' perceptions of their own femininity, body image and physical self efficacy. Aerobic dance might enhance girls' physical self perception and therefore could be an activity through which positive psychological results could be attained (Daley & Buchanan, 1999). Another study by Bartholomew and Miller (2002) supports the affective benefits of submaximal, continuous exercise in aerobic dance classes which extend to self selected aerobic dance classes. Aerobic dance appears to be an activity which could accomplish the fulfillment of the main recommendations and enhance effectiveness in promoting cardiorespiratory fitness (Flores, 1995; Li & Dunham, 1993; MacConnie, Gillian, Geenen, & Pels, 1982).

From the point of view of educational and other values, dance is acknowledged for other reasons than aerobic dance is. They are the aesthetic, cultural, social, emotional and artistic benefits of dance (Hanna, 1999; Purcell, 1994; Sanderson, 1996; Smith-Autard, 2002). Since these contribute to progress in the learning process (Chen, 2001; Graves & Townsend, 2000; Koff, 2000; Richardson & Oslin, 2003), they belong among the main points of advocacy for dance in the school curriculum. In dance and especially creative dance, composing dances is emphasised (Morin, 2001), because every dance movement is the result of a range of useful decisions on how the dance movement uses space, time, energy and partnership of pupils. Dance gives pupils an opportunity to express their ideas, feelings and views (Purcell, 1994).

The aims of our study were twofold: firstly, to compare the physical load in dance and aerobic dance lessons to the recommendation of the minimum of 50% of class time being physically active (USDHHS, 2000) and secondly, to identify how the students' role in the educational process affects girls' engagement in PA.

METHODS

Participants and setting

One middle school and two high schools in the Czech Republic and two middle schools and three high schools in Poland participated in this study. Girls from the 6th through the 11th grades (n = 241) gave their consent to participate (M ± SD age: 16.0 ± 1.6 years; height: 1.65 ± 0.06 m and weight: 53 ± 8.2 kg). In total, 241 girls participated in two types of PE lessons, 171 were eliminated since they submitted incomplete monitoring record sheets. Only two girls refused to participate in the study. In compliance with the Czech and Poland national curriculum, girls attended PE lessons twice and three times a week, respectively, in single sex groups. Each lesson took 45 minutes. Lessons were taught by 9 university students studying in their last year of the master degree programs in PE. The lesson content which was dance or aerobic dance was accompanied by music.

Measurements

A heart rate telemetry system was used to measure PA during lessons. For the confirmation as to whether progressive intervention was implemented, a standardized questionnaire was distributed.

HR monitor (Polar, Oy, Kempele, Finland): Heart rate was measured at 5 s intervals using a Polar S610™ heart rate telemetry system. Higher load (heart rate above [220 – age] × 0.85), medium load (in the zone of 70–84% of maximal heart rate), average heart rate during a 45 minute PE lesson were registered. The values express physical load in terms of zones – aerobic, anaerobic threshold and "redline", which are applied in PE lessons by Swaim and Edwards (2002). In order to compare physical activity during the lessons to Healthy People 2010 recommendations with the minimum of 50% of class time being physically active (USDHHS, 2000), target heart rate zone and the percentage of PE lessons time in the target zone were calculated. Target heart zone was partially determined by the American College of Sports Medicine guidelines (2000) as over 60% of maximum heart rate (220 – age).

Questionnaire: At the end of each lesson, participants were to complete a standardized questionnaire asking 24 dichotomous questions. The questions covered six primary dimensions (cognitive, emotive, health, social, attitudinal, and creative) and a supplementary dimension of the "student's role". The reliability and validity of this questionnaire have been reported elsewhere

(Frömel, Vašendová et al., 2002). According to the data obtained from each dimension of the questionnaire, the changes in the students' role in the teaching process were assessed. This included measures of student satisfaction with the PA in PE lessons, the teacher's role as a facilitator of learning, freedom to make decisions, dialogue between the student and the teacher, and the students' central role in the learning process.

Procedure

In the experiment, each class took part in 2 types of PE lessons. The first type was traditional PE involving standard teaching approaches using dance or aerobic dance with appropriate musical accompaniment. The content of the PE lessons was adjusted to the abilities and interests of the students, the student teachers, the physical environment and current curricular demands and varied in different dance styles (modern, latin, hip-hop etc.) and tempo of chosen music accompaniment.

The progressive series of PE lessons had structure and content similar to the traditional lessons. Yet "increasing the student's role in the educational process" was added as an extra variable. The educational process involved more decision making, self directed activity, critical and creative thinking, problem solving, metacognition, social development, and self assessment.

The main instructions given to the teachers on how to teach the progressive physical education lessons were:

- to incorporate individualized episodes that encourage cooperation,
- provide students with more involvement in the lesson's management and encourage the students to accept responsibility for their results,
- to allow the students to opt for different alternatives,
- to increase students' autonomy for decision making, creativity and self realization,
- to enhance peer assessment.

To achieve these aims, student teachers were allowed to use the whole range of teaching styles (Mosston & Ashworth, 2002).

Before starting the lesson HR monitors were adjusted to each monitored student. Heart rate monitors were put on according to the instructions. All monitors were set up by the research team members and started just prior to the lesson. The course of the lesson was not interrupted by this procedure. At the end of the lesson students took approximately 5 minutes to complete the questionnaire.

Data analyses

The Statistica 6.0 program was used for data processing. For data analysis we used basic statistical characteristics and the Wilcoxon test for nonparametric data from the questionnaire. For association between independent and dependent variables we used the repeated measure ANOVA and Scheffé post-hoc test ($p \leq 0.05$). The type of lesson with two categories (traditional and progressive lessons) and content with two categories (dance and aerobic dance lessons) belong among independent variables. As dependent variables, mean heart rate and heart rate zones are considered. As a complementary characteristic for the explanation of "effect size", we used the coefficient ω^2 (Tolson, 1980) and the coefficient η^2 in agreement with recommendations by Morse (Morse, 1999).

RESULTS

Statistically significant differences were found between traditional and progressive dance [$T = 6.93$; $p < 0.001$, $\eta^2 = 0.06$] and aerobic dance [$T = 8.90$; $p < 0.001$, $\eta^2 = 0.07$] during PE lessons in the dimension of the student's role. Higher score (more points) in this dimension was obtained in progressive PE lessons in comparison with traditional PE lessons. These confirmed that progressive intervention had been put into effect (Fig. 1).

Furthermore, the intervention aimed at "increasing the student's role" in PE lessons did not cause any decrease in heart rate (mean HR) nor PA intensity in progressive type lessons ($F = 0.62$; $p = 0.431$; type × content $F = 0.54$; $p = 0.464$). Mean heart rate was 137.56 ± 12.48 beats·min^{-1} in traditional and 139.25 ± 12.87 beats·min^{-1} in progressive dance PE lessons. In aerobic dance PE lessons, the girls' mean heart rate was 149.94 ± 20.29 beats·min^{-1} in traditional lessons and 150.0 ± 15.52 beats·min^{-1} in progressive lessons.

Differences in time (min.) spent in the zone over 85% of HR_{max} ($F = 0.87$; $p = 0.351$; type × content $F = 2.47$; $p = 0.117$), in the zone 70–84% HR_{max} ($F = 0.08$; $p = 0.777$; type × content $F = 0.58$; $p = 0.445$) and in the zone 60–69% ($F = 2.91$; $p = 0.089$; type × content $F = 0.18$; $p = 0.670$) were not statistically and practically significant (TABLE 1).

The time students spent in the target zone over 60 percent of their maximal heart rate was 32.86 ± 8.29 minutes in traditional dance lessons, 33.77 ± 8.72 minutes in progressive dance lessons, 40.26 ± 5.66 minutes in traditional aerobic dance lessons and 39.07 ± 7.95 minutes in progressive aerobic dance lessons. Analysis of heart rate data revealed that the girls engaged in PA in the target zone 73.03 ± 18.43% of class time in traditional dance lessons and 75.05 ± 19.38% of class time in progressive dance lesson. The girls spent 89.47 ± 12.58% of class time in traditional lessons and 86.83 ± 17.67% of class time in progressive lessons performing aerobic dance.

Fig. 1
Differences between traditional and progressive PE lessons in the dimension of student's role

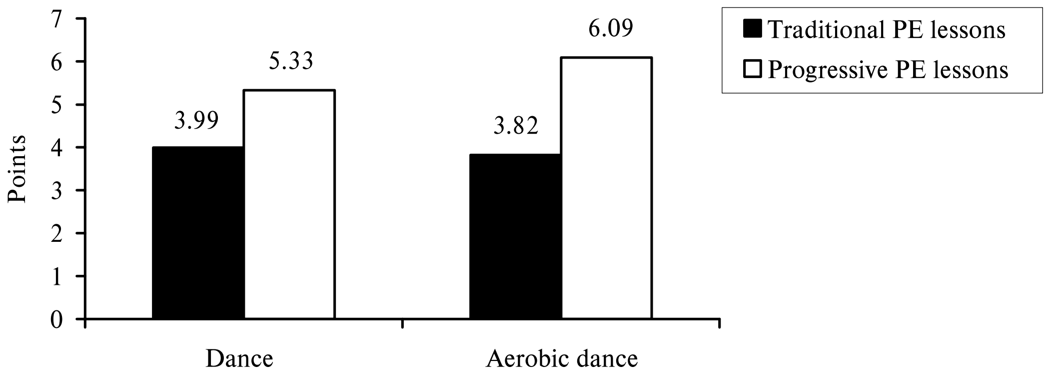

TABLE 1
HR zones and % PE lessons time in HR zones in traditional and progressive dance and aerobic dance PE lessons

Dance physical education (PE) lessons								
Characteristics	**Traditional PE lessons**				**Progressive PE lessons**			
	min.		*% PE lessons time*		*min.*		*% PE lessons time*	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Over 85% HR_{max}	3.56	4.62	7.92	10.26	4.84	5.04	10.76	11.19
70–84% HR_{max} (min.)	14.96	7.63	33.25	16.96	15.56	6.74	34.59	14.98
60–69% HR_{max} (min.)	14.34	5.51	31.87	12.25	13.37	4.70	29.70	10.44
Aerobic dance physical education (PE) lessons								
Characteristics	**Traditional PE lessons**				**Progressive PE lessons**			
	min.		*% PE lessons time*		*min.*		*% PE lessons time*	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Over 85% HR_{max}	8.45	10.10	18.78	22.45	8.13	8.43	18.06	18.74
70–84% HR_{max} (min.)	21.0	10.27	46.67	22.83	20.72	8.31	46.05	18.47
60–69% HR_{max} (min.)	10.81	9.54	24.02	21.20	10.22	6.55	22.72	14.56

Legend: M = mean, SD = standard deviation, HR_{max} = maximal heart rate.

DISCUSSION

The data were assessed in relation to PA recommendations and according to how the students' role in the educational process affects their engagement in PA. The difference between traditional and progressive lessons was confirmed by higher scores in the student's role dimension of the questionnaire. In total, progressive intervention did not negatively affect PA in progressive PE lessons. The progressive intervention was carried out in dance and aerobic dance PE lessons similarly. In both lessons, there were not significant differences between traditional and progressive PE lessons. This result is surprising in the case of dance lessons, because the content of these lessons incorporated girls' involvement both in composing the whole or a part of a dance and its performance; usually with the emphasis on choreography, the result is less PA (Stratton, 1997). We are however aware that the higher, although not significant, average heart rate and other heart rate characteristics in progressive dance lessons could have been caused by other factors such as emotional stress while performing dance.

PA in aerobic dance lessons was higher than in dance lessons, which is in agreement with the primary orientation of these types of PA. Aerobic dance is mainly focused on improving aerobic endurance and determines the whole body's movement in virtue of its nature. Dance lessons emphasize aesthetics of the demonstration of the movement, awareness of space, of different rhythms, of one's own body, and a right posture more than aerobic dance lessons do.

PA in aerobic dance lessons met the health recommendations for adolescents (aged 11–21) of 30 minutes at a moderate to vigorous level of exertion (Sallis & Patrick, 1994). Girls spent more than 50% of class time in moderate – vigorous PA in both traditional and progressive aerobic dance lessons and accomplished the Healthy People 2010 recommendation (USDHHS, 2000). The accomplishment of the main recommendations and effectiveness in promoting cardiorespiratory fitness in aerobic dance lessons was confirmed also by Li and Dunham (1993) and MacConnie et al. (1982). However, moderate to vigorous PA for three or more sessions per week is recommended for improvement in aerobic fitness (Sallis & Patrick, 1994). I agree with Stratton (1996) that this aim can not be fulfilled only by PE considering the usual frequency of only two PE lessons a week.

Although the level of PA in dance lessons was lower than in aerobic dance lessons, students still spent 50% of PE class time being physically active (USDHHS, 2000), met the health recommendation for adolescents (aged 11–21) of 30 minutes of moderate to vigorous level of exertion (Sallis & Patrick, 1994) and accomplished the requested vigorous level of exertion in PE lessons (Simons-Morton, O'Hara, Parcel, Baranowski, & Wilson, 1990). The level of PA in dance lessons in this study seems to be high in comparison to a study by Hodges Kulinna et al. (2003) where a lower average heart rate (131.13 ± 12.83 bpm) and percentage of time in the target zone in dance lessons in high school students were reported. Their results are consistent with Stratton's (1997) findings that dance belongs among PE activities with the lowest amount of moderate and vigorous PA. Mean heart rate in dance lessons is similar to mean heart rate in different indoor PE classes in Portugal in girls of the 7th grade (Wang, Pereira, & Mota, 2005).

Our findings of a high level of PA in dance and especially in aerobic dance lessons are supported by the Hodges Kulinna et al. study (2003) when secondary school girls were more active in individual activities. Other studies (Fairclough & Stratton, 2005a; Fairclough, 2003; Stratton, 1997), however, reported team games as activities more valuable to reach PA recommendations, encompassing whole body movement at different speeds, whereas the nature of movement activities (dance and gymnastics) emphasizes aesthetic awareness and control. Yet, in the case of dance lessons there are also other curricular goals desired than only the PA goals, whereas aerobic dance lessons are more efficient in achieving PA goals and recommendations.

CONCLUSION

This study shows that progressive intervention did not negatively affect PA and confirms that both aerobic dance lessons and dance lessons can be an effective means of how to achieve PA and fitness goals in PE. Results from this study suggest that the increased student's role can help to fulfill other PE goals such as responsibility for decision making and creativity along with promoting PA and cardiorespiratory fitness in student oriented lessons. Dance lessons, in spite of a different main objective, may contribute to achieving critical PA recommendations and total daily or weekly PA. We believe that the increased student's role in PE classes and students' choice of activities can effectively motivate students to perform and sustain PA for life. Aerobic dance and dance seem to be particularly influential contents of PE lessons that can enhance promoting PA in girls.

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VYUČOVACÍ JEDNOTKY TANCE A TANEČNÍHO AEROBIKU: JAK ROLE ŽÁKA OVLIVŇUJE POHYBOVOU AKTIVITU DÍVEK VE VYUČOVACÍM PROCESU

(Souhrn anglického textu)

Hlavním cílem školní tělesné výchovy je podporovat celoživotní pohybovou aktivitu (PA) a zvyšovat pohybovou gramotnost dětí. Edukační proces je v tělesné výchově (TV) naplňován pohybově aktivním zapojením žáků,

a proto by měla být převážná část jednotek TV trávena aktivní pohybovou činností s odpovídajícím tělesným zatížením. Cílem této studie je zjistit, zda tělesné zatížení v jednotkách tance a aerobiku splňuje doporučení strávit alespoň 50 % času pohybovou aktivitou střední a vysoké intenzity (USDHHS, 2000) a zda role žáka v edukačním procesu ovlivňuje pohybovou aktivitu dívek. 241 děvčat absolvovalo program tvořený tradičními a progresivními vyučovacími jednotkami tance a aerobiku. Srdeční frekvence děvčat byla v průběhu vyučovacích jednotek monitorována systémem Team Polar. Děvčata trávila více než 50 % času pohybovou aktivitou střední a vysoké intenzity v tradičních i progresivních vyučovacích jednotkách tance i aerobiku. Výsledky této studie potvrzují, že zvýšená role žáka napomáhá plnit cíle TV, jako například odpovědnost za vlastní rozhodování a tvořivost, aniž by docházelo ke snižování pohybové aktivity ve vyučovacích jednotkách.

Klíčová slova: srdeční frekvence, tradiční a progresivní jednotky, rozhodování, tvořivost.

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2005 – Ph.D. in Kinantropology, Dissertation thesis: Dance in contemporary system of physical education at schools.

Since 2007 – research and pedagogical assistant at Palacký University, Olomouc, Faculty of Physical Culture, Center for Kinanthropology Research.

Scientific orientation

Research in Kinanthroplogy; focus on Physical Education at schools, monitoring and analysis of the physical activity in children, adolescents, adults and seniors, intervention physical activity programs, physical activity in relation to lifestyles and the environmental attributes.

Member of international research teams: IPAQ – International Physical Activity Questionnaire, IPEN – International Physical Activity & Environment Network and EUNAAPA – European Network for Action on Ageing and Physical Activity.

First-line publications

Pelclová, J., Frömel, K., & Křen, F. (2005). Physical activity and inactivity in boys and girls of different types of school in the Czech Republic. *Journal of Coimbra Network on Exercise Science, 2(1)*, 8–12.

Pelclová, J., Frömel, K., Sigmundová, D., & Kudláček, M. (2007). The relationship between neighborhood environment, demographic variables, and physical activity level in Czech high school students [Abstract]. *Acta Universitatis Palackianae Olomucensis. Gymnica, 37(2)*, 90.

Pelclová, J., Frömel, K., Sigmundová, D., Chmelík, F., & Pelcl, M. (2008). *Variability of year round physical activity in high school girl. In 2nd International congress on physical activity and public health.* Amsterdam: VU university media center, Centers for disease control and prevention.

Mitáš, J., Frömel, K., & Pelclová, J. (2006). Does the ownership of a car or a bicycle influence physical activity of the Czech Republic inhabitants? [Abstract]. *International Congress on Physical Activity and Public Health*, 123.

Mitáš, J., Frömel, K., & Pelclová, J. (2006). Physical activity of the inhabitants of the Czech Republic in relation to the size of the community, type of residence and to the family status [Abstract]. *Active Living Research 2006 Annual Conference*, 53–54.

INSTRUCTIONS FOR MANUSCRIPT

The Acta Universitatis Palackianae Olomucensis. Gymnica is an independent professional journal. The content of the magazine is focused on presentation of research notifications and theoretical studies connected with the problems of kinanthropology. The Editorial Board is looking forward to all manuscripts written on the above subject.

General instructions

The text of the contribution is in English. The contribution is not to exceed a maximum limit of 15 pages (including tables, pictures, summaries and appendices). A summary will be in the Czech language, and by rule 1 page at the most.

The text is to be presented in MS Word editor (CD) and also as a printout.

All contributions are reviewed anonymously.

Interface of the contribution

Title of the contribution, name(s) of its author(s), workplace, date of handing in the contribution, summary of the text in English, key words.

Text of the contribution

Names of individual chapters are to be written in capital letter from the left margin. References to quoted authors see a brief from the publication manual http://www.gymnica.upol.cz.

Epilogue of the contribution

A reference summary (see a brief from the publication manual http://www.gymnica.upol.cz), address of the main author, summary including the key words.

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To be written on separate pages. A table is to be marked as TABLE 1 with its name below, write on the left margin above the table (the same applies for appendices). A picture is to be marked as Fig. 1, write from the left above the picture (the same applies for a graph).

All contributions to Acta UPO Gymnica must have been corrected by an English expert before being submitted to us. Please enclose an official confirmation of this correction. If possible we would appreciate the text in the original language.

We look forward to our further cooperation!

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