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BURNOUT IN PHYSICAL TRAINING TEACHERS A MACRO-PATH OF PROFESSIONAL BURNOUT

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Submitted in January, 2004

The investigations were carried out in male and female physical training teachers from Cracow and Wieliczka, first-year Academy of Physical Educations students from Cracow (post-bachelor and extramural course) and participants in three post-graduate courses (N = 256) between February and October, 2003. The syndrome was diagnosed based on the MBI Maslach questionnaire. Empirical material was analyzed using variance analysis, the non-parametric test of difference significance and cluster analysis.

More than one half of physical education teachers (58.6%) were demonstrated not to experience professional burnout, while burned-out individuals accounted for 27.4% of the sample; the process of burnout was generally not dependent on the gender variable. Both the scope and intensity of burnout were found to be lower as compared to general education teachers. The initial reaction of physical training teachers to specific stress was a loss of job – related satisfaction. The author failed to determine a burnout macro-path for physical training teachers; the missing T2 segment requires elucidation based on a larger sample of material.

Keywords: Professional burnout, physical training teacher.

"It represents an erosion of values, dignity, spirit, and will – an erosion of the human soul. It is a malady that spreads gradually and continuously over time, putting people into a downward spiral from which it's hard to reverse."

Ch. Maslach & M. Leiter, 1997, 17

INTRODUCTION

The term "burnout" was recognized as a scientific notion less than 30 years ago, when it was employed simultaneously and independently by a psychiatrist, Herbert J. Freudenberger, and a social psychologist, Christine Maslach (Tucholska, 2001).

The burnout syndrome, which originally emerged as a social issue, has gained almost a score of conceptualizations and operationalizations (see: Tucholska, 2003, 19–55). The symptoms of burnout described by various investigators have been collected by Cherniss (Noworol, 1998, 215–216), and by other authors (see: Tucholska, 2003, 38–39). In the literature on the subject, the most popular proposal is that presented by Maslach, who was the first to develop a coherent concept of the burnout syndrome and constructed a tool for measuring the phenomenon, i.e. the Maslach Burnout Inventory (MBI) (Maslach & Jackson, 1986).

According to her concept, the burnout syndrome is the reaction of the organism to chronic emotional stress resulting from the collapse of adaptation processes to one's work environment. "It is a syndrome of physical and mental exhaustion, which includes the development of negative concepts of 'I', a negative attitude towards one's work, a loss of emotions and contact in relations with other people" (Maslach, 1978, in Noworol, 1989, 124–125).

Stress is a consequence of interpersonal contacts occurring in various relations that result from one's work contract. Social professions, such as nurses, physicians and teachers, are believed to be especially endangered with specific stress. Another group includes managers, high-level office workers and banking sector employees (Noworol, 2000), as well as individuals who highly value professional work as such. These people are inclined to make special sacrifices; they often ignore their own needs and are at risk of deep disappointment and frustration when faced with numerous stresses and an unfavorable work environment (Paines, 1993, in Tucholska, 2003). Negative effects of burnout may spread to other spheres of the life of the individual suffering from the syndrome, leading to gradually increasing family problems, an escape into illness, substance abuse and development of psychogenic problems (Maslach, 1997, in Kliś & Kossewska, 1998).

According to the concept developed by Maslach, the burnout syndrome is a multi-dimensional phenomenon. Its three dimensions are:

Emotional Exhaustion – EE: A subjective sense of exhaustion or depletion of one's resistance and emotional resources and a loss of the "joie de vivre". Individuals who manifest this dimension of burnout show strong emotional reactions to weak stimuli, are easily engaged in conflicts, become uncommunicative and increasingly more emotionally involved in situations that require professional interventions.

Personal Accomplishment – PA: A subjective assessment of the value of one's professional work. The dimension – the realm of positive feelings – is negatively correlated with the other two dimensions; in the course of the analysis and interpretation of MBI scores, the scale is reversed. The Negative Sense of Professional Achievement Scale (NSPAS) is a tool for diagnosing a decreased sense of one's competencies or achievements at work.

Depersonalization – DP: It is manifested through negative, cool, distanced (or even outright cynical) behaviors towards individuals, with whom the affected person maintains work-associated relations. Any problems pertaining to other people are perceived as justly deserved, for which the said others should suffer consequences (Noworol, 2003, an unpublished manuscript).

The phenomenon of burnout progresses with time and is manifested in various ways in particular individuals. According to Maslach, the presented symptom is an increasing emotional exhaustion, followed by loss of satisfaction over one's professional achievements. In consequence of the situation, the process of depersonalization begins – the affected person distances himself from specific stress posed by another human being (Noworol, 2000). Burned-out individuals are defined as persons manifesting the triad of the factors characteristic of the multi-dimensionally analyzed syndrome (Krawulska-Ptaszyńska, 1992).

---

emotional exhaustion
$\Rightarrow$ *negative sense of professional achievements*
$\Rightarrow$ *depersonalization*

According to McConnell, the tri-dimensional burnout syndrome develops at three levels (McConnell, 1982, in Noworol, 1989).

Level 1:
Mild, short-term symptoms that appear incidentally;
- the symptoms may be relieved via relaxation or work breaks.

Level 2:
The symptoms are intensified and occur more regularly;
- the typical strategies of symptom alleviation, such as, for example, weekend rest and recreation, cease to be successful;
- the recovery and ability of continued self-care require an additional effort.

Level 3:
Continuous signals of burnout, physical and mental problems appear (depression, manic states);
- any efforts directed towards relieving the symptoms on one's own are pointless;
- any professional help does not provide an immediate effect.

Based on the theory developed by Maslach, Golembiewski determined a contrary direction of the burnout pathway. In his opinion, depersonalization, also understood as the effect of stress that leads to a lowered sensitivity threshold, and in consequence to the development of distancing behaviors, is the first factor to appear. The reaction of other fellow-workers to the increasing coolness and distance in professional contacts with the affected person with progressive burnout leads in the latter to a decreased sense of self-esteem and professional achievements. As a result of intensified symptoms, the employee starts to react in the emotional sphere, which leads to emotional burnout (Noworol, 2000).

---

depersonalization
$\Rightarrow$ *negative sense of professional achievements*
$\Rightarrow$ *emotional exhaustion*

The burnout process described by Maslach and Golembiewski may be schematically represented as a system of pathways that have reverse directions. In view of this fact, these theories have been termed "facing theories" (Noworol, 2000).

The seemingly contrary theories have been combined into a comprehensive unity in the four-stage typological model of burnout that has originated from the eight-stage model developed by Golembiewski (Noworol & Marek, 1994).

In the typological model (Fig. 6), the burnout process includes four major stages: T0 (Unaffected by burnout), T1, T2, T3 (Burned-out), with the T1 and T2 phases being complex. The progressive burnout process may proceed along various paths that are specific for a given individual (a micro-path), or a professional group (a macro-path), which is depicted in Fig. 6. The facing theories constitute two separate paths in the four-stage model – the theory developed by Maslach describes the burnout process in the so-called helping professions, while the solution proposed by Golembiewski explains the intensification of the syndrome chiefly in the managerial professions (Noworol, 2000).

Polish studies on the phenomenon of burnout in teachers chiefly concentrate on analyzing the problem in relation to methods of coping with stress, some personality and temperament-associated determinants,

sexual identity, social support, level of education offered and type of school (public schools, special education schools), sex, age, education, as well as the time of practicing the profession (Krawulska-Ptaszyńska, 1992; Sęk, 1994, 1996; Golińska & Świętochowski, 1998; Kliś & Kossewska, 1998; Przybyła, 1998; Mandal, 1999; Sekułowicz, 2002; Tucholska, 2003). Świętochowski (2001) investigated the effect of burnout on non-clinical somatic disorders among teachers. Tucholska (2003), in her cross-sectional study of general education school-teachers (N = 256), included a variable of the subject taught; the number of investigated physical training teachers was N = 16. Using the concept developed by Golembiewski, she also proposed a sequence of increasing burnout symptoms in the studied group.

The aim of the present report was to answer the question of how the burnout syndrome developed in physical training teachers and to attempt to define the macro-path of burnout in teachers of this subject.

Two hypotheses were formulated:

In view of the specific character of their work, the population of female and male physical training teachers manifests the phenomenon of burnout.

The course of the burnout macro-path among physical training teachers is in agreement with the burnout path described by Maslach, the latter illustrates the process as occurring in social professions.

METHOD

The study employed the method of diagnostic polling and was carried out between February and September, 2003, among physical training teachers from various Cracow and Wieliczka schools (elementary, junior high and high), students of the Cracow Academy of Physical Education (freshmen attending the post-baccalaureate extramural program, students of extramural courses) and participants of three post-grad courses for physical training teachers organized by Province Postgraduate Training Center for Teachers in Cracow and Nowy Sącz (N = 256; women N = 144, men N = 112).

Among the respondents, the most numerous group consisted of physical training teachers employed by elementary schools (38.7%) in large urban centers (province capital – 72.3%, district towns – 19.1%, rural areas – 8.6%). The mean age of the respondents was 36.9 years, the mean duration of employment in school amounted to approximately 13 years (TABLE 4), with the range of age and employment duration of 23–57 and 1–40 years, respectively.

To diagnose the burnout syndrome, the Maslach Burnout Inventory (MBI Form Ed.) was employed; the scale had been adapted to Polish conditions by Noworol (1994; an unpublished manuscript). The MBI questionnaire allows for determining the level of burnout as a consequence of chronic emotional stress in a work setting.

The questionnaire consists of 22 statements grouped into three subscales:

- Emotional Exhaustion (EE) – 9 items;
- Negative Sense of Professional Achievement (NSPA) – 8 items;
- Depersonalization (DP) – 5 items.

Using a seven-point scale, each responder determines the frequency of experiencing a given state. The scale ranges from 0 – never, to 6 – every day; the intermediate values denote the frequency of once/several times per year, month, and week.

The empirical material was analyzed using the variance analysis, the non-parametric U Mann-Whitney test (Ferguson & Takane, 1999), as well as the cluster analysis (the k-mean method of Mac Quin) (Noworol, 1987) and employing the SPSS/11 statistical software.

RESULTS

In the investigated population of physical training teachers, the gender variable basically did not affect the structure of the burnout phenomenon. Only in the group of women was emotional exhaustion (EE) slightly more pronounced ($p < 0.05$) (TABLE 1). The mean values of the other dimensions (NSPA and DP) did not differ significantly.

TABLE 1
The burnout structure among female and male teachers of physical training

MBI	Females N = 144		Males N = 112		p
	$\bar{x}$	SD	$\bar{x}$	SD	
EE	13.56	8.302	11.70	8.560	0.042
NSPA	11.53	7.682	10.36	6.865	0.255
DP	3.85	3.847	4.42	4.026	0.204

EE - emotional exhaustion, NSPA - negative sense of professional achievement, DP - depersonalization

TABLE 2
Burnout among physical training teachers – the cluster analysis

Cluster	Burnout among physical training teachers						
	N	%	$\bar{x}$	Me	SD	min	max
I.	150	58.6	18.67	19.00	8.27	1	45
II.	1	0.4	105.00	105.00	–	105	105
III.	30	11.7	30.53	28.50	7.14	18	49
IV.	6	2.3	44.33	44.50	8.64	30	54
V.	69	27.0	44.14	42.00	10.60	29	74
Total	256	100	27.86	26.00	15.14	1	105

TABLE 3
Burnout of physical training teachers – the statistical analysis of dimensions from the Maslach Burnout Inventory (MBI) within particular clusters (emotional exhaustion EE, negative sense of professional achievement NSPA, depersonalization DP)

MBI	Cluster										Total	
	I.		II.		III.		IV.		V.			
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
EE	8.9	5.39	53.0	–	8.2	3.81	21.5	2.17	21.7	6.68	12.7	8.45
NSPA	6.8	4.29	34.0	–	18.7	5.41	10.7	5.82	16.6	6.54	11.0	7.34
DP	2.9	2.97	18.0	–	3.7	2.81	12.2	5.04	5.9	4.30	4.1	3.93

TABLE 4
Cluster description: gender, age and duration of employment among physical training teachers

Cluster	Gender				Age		Duration of employment	
	Females		Males					
	N	%	N	%	$\bar{x}$	SD	$\bar{x}$	SD
I.	79	52.7	71	47.3	36.2	2.97	12.4	8.10
II.	0	0	1	100	50.0	–	25.0	–
III.	16	53.5	14	46.7	38.8	8.54	14.2	8.46
IV.	4	66.7	2	33.3	33.0	7.18	7.3	4.84
V.	45	65.2	24	34.8	37.5	7.82	12.9	7.50
Total	144	100	112	100	36.9	7.86	12.7	7.97

Subsequent statistical analyses allowed for defining five clusters in the studied population (TABLE 2). The clusters were homogenous with respect to burnout level and they grouped individuals characterized by the same burnout pattern, i.e. with similar values of the three dimensions: emotional exhaustion (EE), negative sense of professional achievement (NSPA) and depersonalization (DP) (TABLE 3–4). In view of the fact that the burnout process in female (N = 144) and male physical training teachers (N = 112) was similar (ANOVA, $F = 0.881$, $p > 0.05$), the variable of gender was disregarded in further analyses.

Among the respondents, 58.6% were found not to be burned out (Cluster I; N = 150) (TABLE 2–3, Fig. 1). Working with children was a clear source of satisfaction to this group of educators – their mean value of the negative sense of professional achievement dimension ($\bar{x}$ I. NSPA = 6.8) was almost twice as low as the mean value for the entire population ($\bar{x}$ NSPA = 11.0). Characterized by a relatively low degree of burnout, these teachers were capable of maintaining the closest contacts with their pupils – the mean value of the depersonalization dimension DP ($\bar{x}$ I. DP = 2.9) was the lowest in this cluster (TABLE 3).

Clusters II and V (N = 70) grouped burned-out teachers (27.4%), who experienced symptoms of emotional exhaustion and depersonalization, while clearly deriving no satisfaction from their work. In the remaining teachers – Cluster III and IV (N = 36; 14.0%) the burnout syndrome was beginning to manifest itself in diverse ways (TABLE 2–3).

Cluster II was a one-element cluster (TABLE 2–4). Very high values of the three MBI dimensions: EE = 53.0, NSPA = 34.0 and DP = 18.0, proved a very high, outright extreme burnout level in one respondent, a male teacher of a junior high school employed for 25 years (Fig. 2).

The population of physical education teachers grouped in Cluster V was also characterized by high mean values of the triad of factors that together formed the phenomenon of burnout. Considerable emotional exhaustion was clearly seen ($\bar{x}$ V.EE = 21.7) (TABLE 3).

Fig. 1
Graphic presentation of three burnout dimensions in Cluster I. N = 150 (emotional exhaustion EE, negative sense of professional achievement NSPA, depersonalization DP)

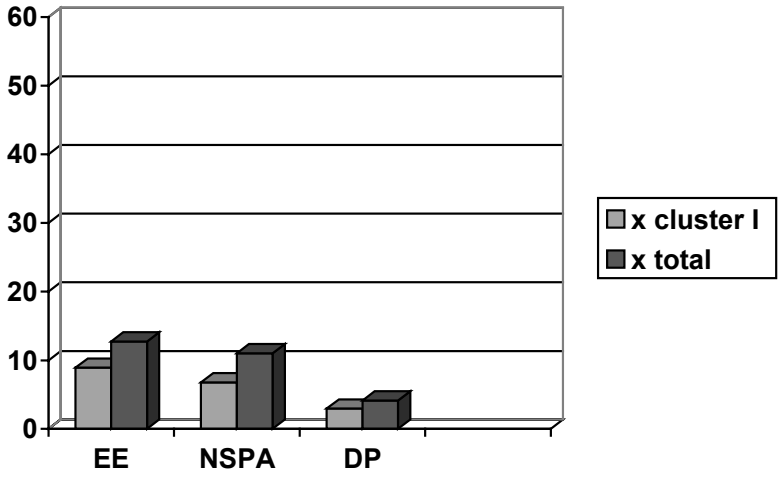


Fig. 2
A graphic presentation of three burnout dimensions in Cluster II. N = 1 (emotional exhaustion EE, negative sense of professional achievement NSPA, depersonalization DP)

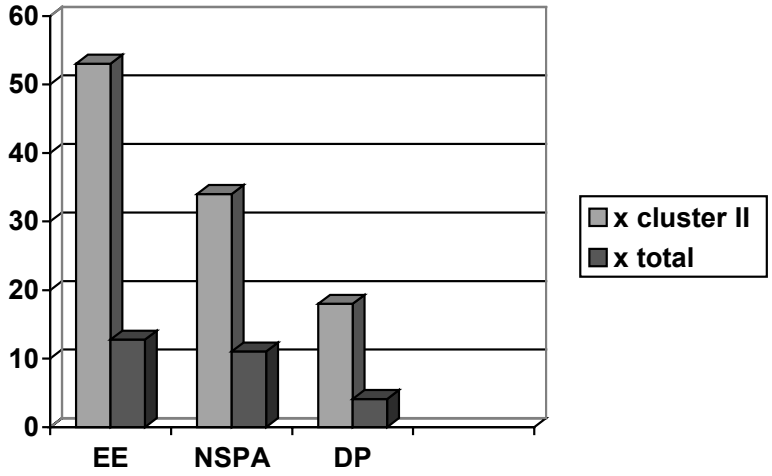


Fig. 3
Graphic presentation of three burnout dimension in Cluster V. N = 69 (emotional exhaustion EE, negative sense of professional achievement NSPA, depersonalization DP)

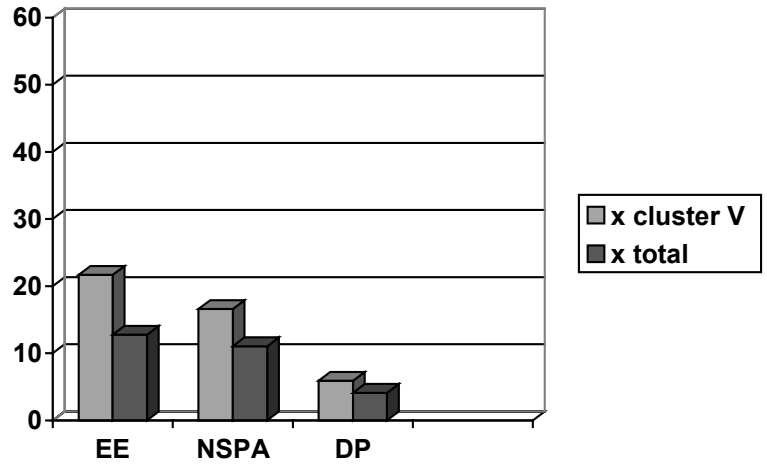


Fig. 4
Graphic presentation of three burnout dimensions in Cluster III. N = 30 (emotional exhaustion EE, negative sense of professional achievement NSPA, depersonalization DP)

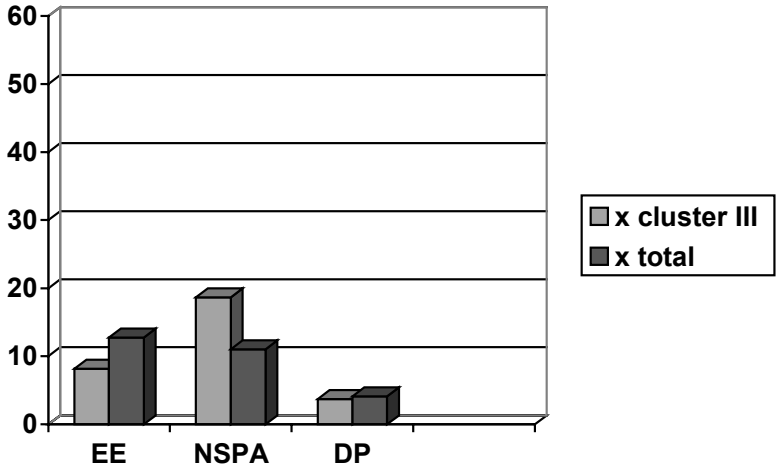
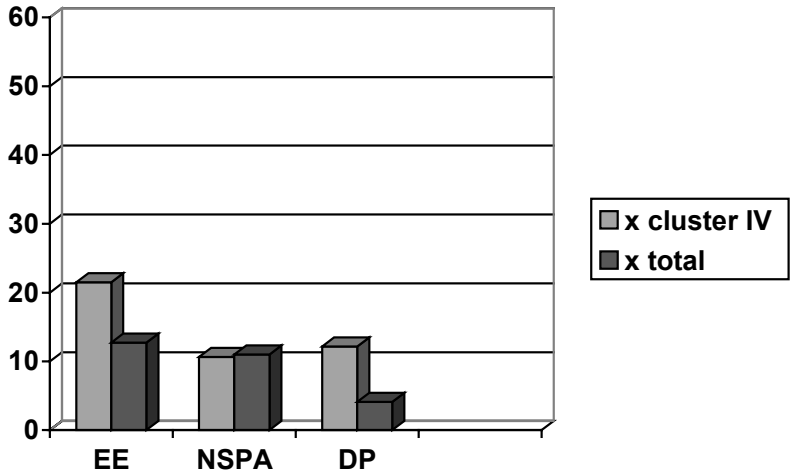


Fig. 5
Graphic presentation of three burnout dimensions in Cluster IV. N = 6 (emotional exhaustion EE, negative sense of professional achievement NSPA, depersonalization DP)



The fully developed syndrome manifested in this cluster is presented graphically in Fig. 3.

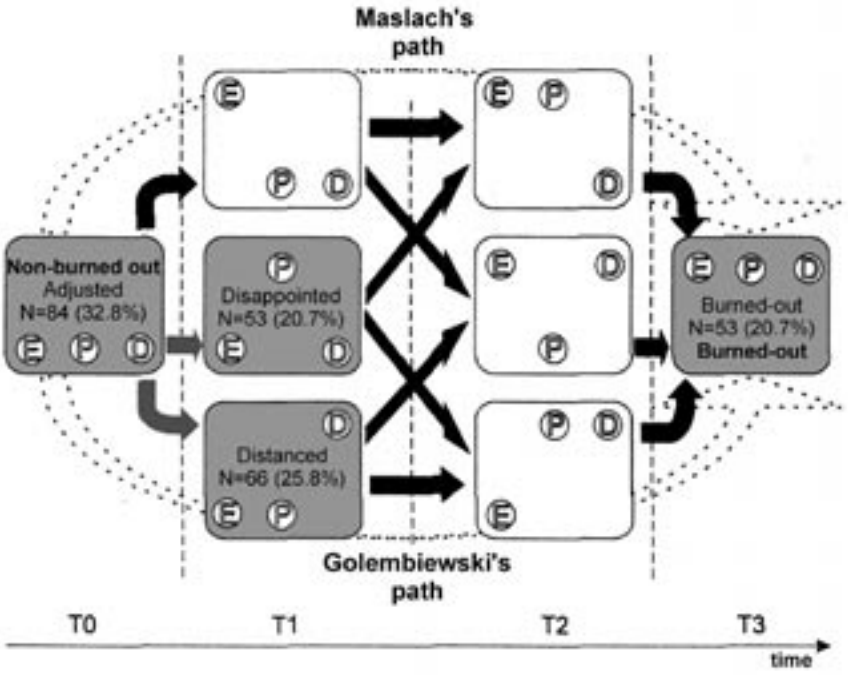
Cluster III (N = 30) included teachers that, despite their low values of emotional exhaustion ($\bar{x}$ III.EE = 8.2; $\bar{x}$ EE = 12.7) and medium level of depersonalization DP, were beginning to experience an absence of professional achievements, gradually losing the sense of value and usefulness of their work ($\bar{x}$ III.NSPA = 18.7) (TABLE 3). These were individuals who were partially burned-out and progressing through subsequent phases of burnout (Fig. 4).

Cluster IV (N = 6) grouped teachers of physical training who – with the progressing burnout process – experienced their first crisis in professional work. Their mean duration of employment was approximately 7 years and their mean age was 33 years (TABLE 4). The teachers reacted to work-related stress with a high level of emotional exhaustion ($\bar{x}$ IV.EE = 21.5; $\bar{x}$ EE = 12.7), which – at the moderate satisfaction level of their work (NSPA) – triggered clear depersonalization (TABLE 3, Fig. 5). The mean value of the DP dimension ($\bar{x}$ IV.DP = 12.2) was twice as high as compared to the mean value characteristic of the population of burned-out teachers from Cluster V and at the same time three times as high as the DP value in the population of non-burned out teachers (Cluster I) (Fig. 3).

Subsequently, based on the four-phase typological burnout model, an attempt was made to determine the macro-path of the burnout phenomenon that developed among teachers of physical training (Fig. 6).

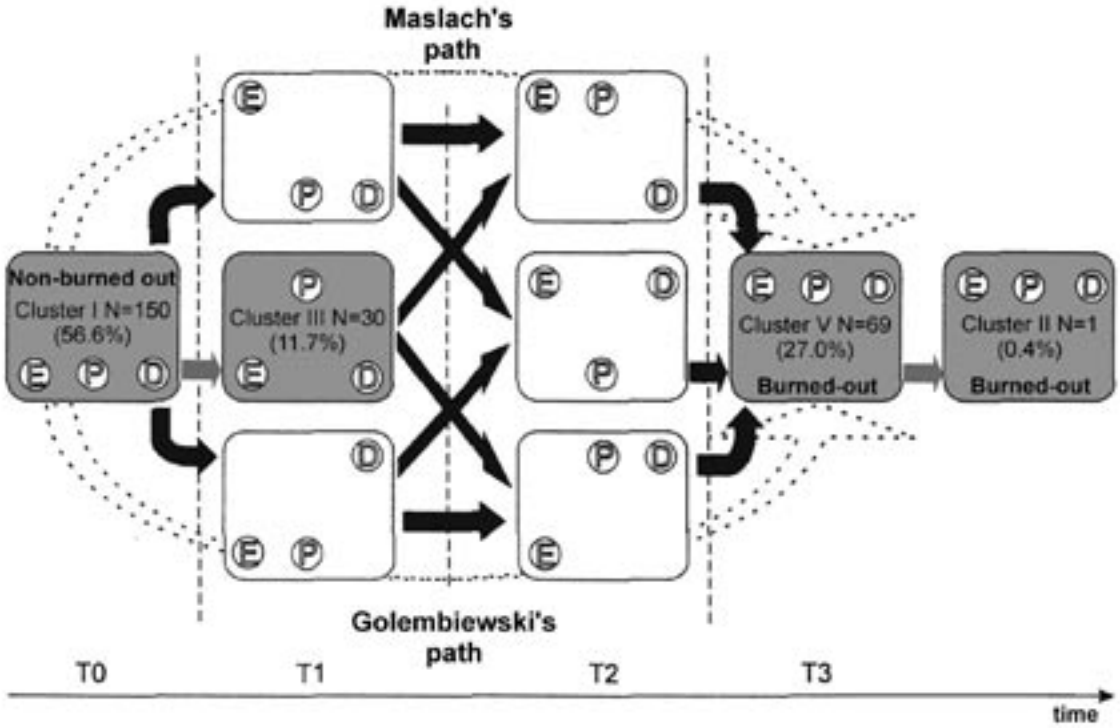
The starting point for the progressive burnout process among physical education teachers is the T0 phase – Cluster I, which is formed by individuals unaffected by burnout (N = 150) (Fig. 1). Subsequently, the T1 phase denotes the process of a gradual increase of dissatisfaction and a loss of professional satisfaction, which – at low values of emotional exhaustion – is accompanied by intensifying symptoms of depersonalization, still

Fig. 6
Macro-path illustrating the course of burnout process in the studied population of physical training teachers (N = 256) plotted using the four-stage typological model with Maslach's and Golembiewski's paths



Legend: E – emotional exhaustion (EE); P – negative sense of professional achievement (NSPA); D – depersonalization (DP); a letter in subscript – a low level of the dimension; a letter in superscript – a high level of the dimension (Noworol, 2000)

Fig. 7
Macro-path illustrating the course of burnout process in the population of general education teachers (N = 256) plotted using the four-stage typological model



Legend: E – emotional exhaustion (EE); P – negative sense of professional achievement (NSPA); D – depersonalization (DP); a letter in subscript – a low level of the dimension; a letter in superscript – a high level of the dimension (Noworol, 2000)

maintained at a level that is somewhat lower than the mean value for the investigated population (Cluster III; N = 30) (Fig. 4). The next segment of the burnout macro-path in physical training teachers (the T2 phase) is unclear and requires further research. The final link of the developing burnout process (the T3 phase) is Cluster V (N = 69) (Fig. 3) that includes teachers characterized by high values of all the three burnout dimensions. The epilogue of the macro-path determined in the typological model is the one-element Cluster II (Fig. 2) that illustrates the extraordinary case of a male teacher who experienced extreme burnout.

Cluster IV (Fig. 5), treated in view of its low sample size (N = 6) as a case study, was not included in the model.

DISCUSSION

The population of physical education teachers employed in various schools (II–IV education level) depicts an interesting portrayal of the analyzed process. With a relatively high number of burned-out teachers (N = 70; 27.4%), a high percentage of the group is constituted by individuals who have not experienced burnout (N = 150; 58.6%). The results of studies carried out among general education teachers indicated a significantly lower percentage of both non-burned out and burned-out individuals: Tucholska (2003) 20.7% and 32.8% (N = 256), Sekułowicz (2002) 6.6% and 13.8% (N = 99), Sęk (1996) 5.9%[1] and 14.3% (N = 119), respectively. Golińska & Świętochowski (1998) found no burnout symptoms in 15.4% of their sample (N = 395); at the same time, more than 1/5 of the respondents indicated a considerable intensity and frequency of experiencing the phenomenon. While performing self-evaluation, "(...) 19% of teachers assessed (...) their burnout level as very high" (Przybyła, 1998, 18); 44% did not notice any symptoms of the syndrome. Mandal (1999) signaled the burnout syndrome symptoms as occurring in more than one half of Polish teachers.

The mean results of the analyzed group of physical training teachers for particular dimensions – emotional exhaustion (EE), negative sense of professional achievements (NSPA) and depersonalization (DP) – are markedly lower as compared to the results obtained by Tucholska (2003)[2]. Similar results were achieved in studies carried out in elementary (ES) and high school (HS)[3] teachers (Kliś & Kossewska, 1998). This suggests that the intensity of burnout is lower among physical training teachers.

The variable of gender basically does not play a differentiating role in the phenomenon of burnout among physical training teachers. The process of syndrome intensification among females and males (the cluster analysis) has a similar course (ANOVA, $F = 0.881$, $p > 0.05$); the analysis of burnout structure indicates only a slightly higher level of emotional exhaustion among female physical training teachers ($p < 0.05$) (TABLE 1). A tendency towards more pronounced psychophysical and emotional exhaustion in female teachers was defined as a trend ($p < 0.056$) by Tucholska (2003).

The above quoted results allow for cautious concluding that physical training teachers as a professional group do not experience negative effects of specific stress to the same degree as other teachers do. When young, the majority of physical training teachers were involved in sports, although not necessarily at the highest level. Personality traits that differentiate between sportspeople and non-sportspeople include extraversion, self-assurance, high motivation towards achievements, low anxiety level and a strong, healthy nervous system; all these factors in combination play a decisive role in resistance to stress (Czajkowski, 1996).

A higher level of mental stamina is associated with a better ability to cope with stressful situations; highly reactive individuals were found to be more susceptible to burnout (Marek, 1993; Noworol & Marek, 1994, in Dworzańska, 1999). Highly reactive teachers clearly derive less satisfaction from working in schools (Golińska & Świętochowski, 1998). The sense of work-associated satisfaction among teachers is at the same time directly dependent on extraversion (Kliś & Kossewska, 1998).

The more dynamic character of physical training lessons and the possibility of conducting them in enclosed (a gym, body-building shop and others) and in open spaces (a sports field, open terrain) exclude monotony. The ability of the teacher to join the students (participation in exercises or games, etc.) – in spite of his mentally and physically cumbersome work – allows him to alleviate stress to a degree. Recreation at leisure, in touch with Nature, sports and mountain climbing (to which teachers of physical training seem to be predisposed) decrease the risk of burnout (Kwiatkowski, 1993; Sęk, 1994).

In comparison to general education teachers, the burnout phenomenon among teachers of physical training is relative more extensive – 27.4% of the investigated group consisted of burned-out individuals. The syndrome often affects highly motivated people, who have given priority to their career over other values (Paines, 1993; Schaufeli & Enzmann 1998, in Tucholska, 2003). The high level of motivation and competitiveness, characteristic of sportspeople (Czajkowski, 1996) may accelerate

[1] calculated based on data presented in TABLE 3.7, page 52 (Sęk, 1996)
[2] EE = 12.7 and 21.07; NSPA = 11.0 and 14.52; DP = 4.10 and 6.41, respectively
[3] ES and HS – EE = 13.9 and 20.9; NSPA = 31.5 and 27.6; DP = 5.7 and 8.0, respectively

burnout in physical training teachers who transfer their ambitions to working with children. Of considerable importance is also the not always adequate prestige of the subject as perceived in the school.

Golińska & Świętochowski (1998) noted a diversified effect of the need of achievement on particular dimensions of the burnout syndrome in teachers. "(...) Highly motivated individuals, in spite of the fact that they pay a lower psychological price (have a lower emotional exhaustion index), or do not experience any particularly high degree of satisfaction, because they perceive this satisfaction through their excessive expectations. If, however, benefits derived from work corresponded to the need for achievement, the satisfaction level would be appropriately higher in such individuals as compared to the others" (Golińska & Świętochowski, 1998, 395).

Based on the obtained results, it has been impossible to conclusively determine the course of the burnout process among physical training teachers (N = 256). The macro-path, constructed using the four-stage typological burnout model (Noworol, 2000) (Fig. 6) is incomplete. The missing segment – the T2 phase – requires elucidation in further studies. There is a possibility of the path branching out – currently it goes straight, from the T0 (individuals who have not experienced burnout) to the T1 phase – or of a change in its direction and its further course in the direction of the ultimate T3 phase (burned-out individuals) along the path determined by Maslach or Golembiewski.

The initial reaction of physical education teachers to specific stress is their gradual loss of the sense of competence and satisfaction derived from their teaching job (Fig. 6), which may be associated with their lack of skills in handling a group of pupils despite their good professional preparation (Krawulska-Ptaszyńska, 1996). Another factor may be found in their irrational professional beliefs, painfully confronted with school practice (Sęk, 1996), as well as in limited funds and resources that hinder the implementation of the teaching program (Niegowska, 2003).

The macro-path determined for the sake of comparison and illustrating the burnout phenomenon of eighth-form elementary school teachers based on the model developed by Tucholska (N = 256; women N = 204, men N = 52) is also incomplete. Using the neural connection (NC) analysis, four homogenous clusters were identified. In adherence to the accepted terminology, the clusters grouped teachers that were Adjusted (32.8%), Disappointed (20.7%), Distanced (25.8%) and Burned-out (20.7%) (Tucholska, 2003). The burnout macro-path of elementary school teachers, including physical training educators, N = 16, is illustrated in Fig. 7.

The path branches out in the T0 phase – two clusters with a similar number of elements (Disappointed – N = 53, and Distanced – N = 66) explain the T1 phase of burnout (Fig. 7). What is alarming is the high number of teachers (25.8%) in whom the initial reaction to specific stress is depersonalization – withdrawal, indifference and loss of concern for their pupils. This is a dangerous symptom in teachers; in the case that these attitudes become fixed, it leads to a loss of necessary interpersonal competencies (Tucholska, 2003, 216–217).

The cluster including the Distanced teachers may include individuals who have been employed inadequately with respect to their professional personality traits (Holland, 1992, in Bańka, 2000; Van Harrison, 1987); in this case, the burnout process develops contrary to the course characteristic for a given group of professionals (Noworol, 2000). Among physical training teachers, this phenomenon is not observed with a sufficient intensity to justify forming a cluster of individuals with a similar configuration of dimensions. The Disappointed, i.e. the second cluster that explains the T1 phase, groups 20% of general education teachers, while less than 12% of physical training teachers (Cluster III), when they experience burnout, begin losing the belief in the meaning and importance of their work (Fig. 6–7).

Other investigations listed in the section on Literature cannot be a reference material in the analysis of the burnout macro-path among physical training teachers. The version of the Maslach Burnout Inventory adapted by Korzon and employed by Sekułowicz (2002), preserved the fourth dimension of the phenomenon – the personal involvement (PI) scale, which had been deleted by Maslach, at the same time subjecting the tool to a small modification (Maslach & Jackson, 1986). Analyzing her results, Sęk used the hierarchic cluster analysis (Sęk, 1996).

Cluster IV (N = 6), which has been disregarded while determining the burnout macro-path of physical training teachers, requires a comment. This cluster groups individuals manifesting symptoms of the first work-related crisis, which usually occur around the 7th year of employment. Among teachers of exact sciences, the phenomenon occurs in the average in the third year of their work (employment duration of 3–5 years), in teachers of the humanities one year later (employment duration of 4–6 years) (unpublished studies, Jagiellonian University, Cracow). One may surmise that in this case, the specific character of the profession of a physical training teacher and his higher resistance to stress are instrumental in the somewhat delayed development of the first work-related crisis.

CONCLUSIONS

1. More than one half of the investigated physical training teachers do not experience burnout.
2. One fourth of the teachers manifest the fully developed burnout syndrome.

3. The gender variable basically does not affect the burnout process among teachers of physical training; female teachers have manifested only a slightly elevated level of emotional and psychophysical exhaustion ($p < 0.05$).
4. Both the extent and the depth of the burnout phenomenon are lower among teachers of physical training as compared to teachers of general subjects.
5. The first reaction of physical training teachers to specific stress is their gradual loss of the sense of competence and satisfaction derived from their work.

In order to determine the macro-path of burnout in physical training teachers, further studies conducted on a larger sample are necessary. In such investigations the general typological model of burnout among staffers in organizations (Noworol, in press) will be helpful. In this case, while statistically analyzing the material, it will be necessary to distinguish a larger group of homogenous clusters.

A complete analysis of the process of physical training teachers' burnout will allow for adopting preventive measures. An appropriately composed teaching syllabus, mostly with respect to the methodology of teaching subjects, as well as well-designed postgraduate workshops addressed to young teachers should alleviate the stress associated with the situation, conditions and expectations of their work environment, thus delaying the development of the syndrome.

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SYNDROM VYHOŘENÍ U UČITELŮ TĚLESNÉ VÝCHOVY – – PROCES ROZVOJE SYNDROMU

(Souhrn anglického textu)

Výzkum byl realizován v období únor až září 2003 mezi učitelkami a učiteli tělesné výchovy v Krakově, Wieliczce, mezi posluchači I. ročníku AWF (SUM; dálkové studium) a účastníky tří kurzů odborného vzdělávání (N = 256). K diagnóze syndromu byl využit dotazník MBI Maslach. Empirický materiál byl zpracován s použitím analýzy variance, neparametrického testu významnosti rozdílů a klastrové analýzy.

Více než polovina učitelů tělesné výchovy ve výzkumném vzorku (58,6 %) nepociťuje vyhoření, pedagogové, u nichž se tento syndrom objevuje, tvoří 27,4 %. Proměnná pohlaví obecně vzato rozvoj syndromu neovlivňuje. Rozsah stejně jako hloubka vyhoření jsou nižší ve srovnání s učiteli všeobecného vyučování. První reakcí učitelů tělesné výchovy na specifický stres je ztráta profesionální satisfakce. Nepodařilo se přesně stanovit proces, v němž k rozvoji syndromu vyhoření u učitelů tělesné výchovy dochází. Vysvětlení chybějící fáze T2 v tomto procesu by vyžadovalo výzkum většího rozsahu.

Klíčová slova: vyhoření, učitel tělesné výchovy.

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POSTURE ASSESSMENT IN CHILDREN OF THE SCHOOL AGE GROUP (7–15 YEARS OF AGE) IN THE OLOMOUC REGION

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Submitted in February, 2004

Within the framework of anthropological research, the diagnosis of posture using the Jaroš & Lomíček somatoscopic method (1957) was carried out in a set of 1201 children of school age as well as foot arch assessment using plantograms as suggested by Klementa (1987). The posture assessment results imply a continuing unfavorable trend of functional disorders of the locomotive system in the present childhood population. Defective posture has been diagnosed in 56% of boys and 37% of girls. The author finds the main cause of the defective posture in the occurrence of muscular dysbalances, namely the upper and lower crossed syndromes. The posture disorders manifest themselves in keeping the head stuck forward, round shoulders, shoulder blades standing out, high pelvis inclination accompanied with lumber lordosis, and in many cases with loose abdominal muscles.

The condition of the foot arch is relatively satisfactory, as the normal foot arch has been found in 85% of the probands.

Keywords: School age group, posture, somatoscopic method, defective posture, muscular dysbalances, foot arch, Olomouc region.

INTRODUCTION

The increasing occurrence of defective posture accompanied by the insufficient fitness of present children and teenagers cannot leave us unconcerned, considering the fact that if not diagnosed and rectified in time, these defects can lead to serious disorders requiring medical treatment. Naturally, the defects of statics, dynamics and defective posture have also appeared in the past, but the present occurrence is substantially higher. This negative trend is mentioned in studies by Riegerová et al. (1993), Přidalová (1997), Jankovská (1998), and Kolisko and Jandová (2002). According to Kubát (1975), defective posture in school age children appears in 50% of the population and Picek (1986) states that defective posture can be found in 85% of our children. The increasing number of children with defective posture, spinal disorders, small deformations and bad locomotive stereotypes is probably in relationship not only to the acceleration of growth and development of the present population, but also with an insufficient amount of movement stimuli, excessive static stress, or one-sided and improper body load, tiredness, excessive sitting and at last but not least with psychological stress. The conditions that influence or cause defective posture do not affect children separately but they mingle and influence one another, which allows us to speak about multifactorial agents.

The mechanical understanding of the origin of defective posture has become a thing of the past. At present, we understand defective posture as a manifestation of a certain muscular dysbalance. Muscular dysbalances appear between two basic groups of skeletal muscles that may be found on the front as well as the rear part of the human body. From this point of view, we differentiate tonic muscles (postural, antigravitational), that function more statically with prevailing isometric contraction, and phasic muscles (phasic, locomotive) with prevailing dynamic function accompanied by isotonic contraction. The origin of muscular dysbalance often manifests itself in, and is also more or less accompanied by, defects of locomotive stereotypes. The most serious change occurring in muscular dysbalance is muscular shortening. The static and dynamic functions of the locomotive system are caused by the imbalance of the postural muscle that tends to stiffen and phasic muscle that tends to slacken. If the hypertrophic postural muscles overwhelm the phasic muscles that tend to slacken the respective part of the body, it is affected by the defective posture. The most frequent types of slackness result from muscular dysbalances. Muscular dysbalances most often occur: in the area of the pelvis and lower limbs (important regarding static function), in the area of the upper trunk, neck and head, and in the area of the lower limbs. Defective posture is characterized by the absence of morphological changes in the skeleton, and it is important that defective posture and its deviations may be rectified by deliberate effort. Therefore, the primary disorder is that of the neuromuscular system and central nervous system. When diagnosing muscular dysbalances and deviations from

upright posture in a child, it is necessary to begin with its rectification. Unfavorable phenomena can be local or have overall effects. Without rectification of the resulting muscular dysbalances and bad locomotive stereotypes, pathogenic stimuli can cause the deterioration of balance and, in the long term, can lead to changes in the tissue structure. In maturity, they manifest themselves as painful vertebrogenic syndromes. Kolisko and Jandová (2002) point out that, at the present time, approximately 70% of the mature population suffer from vertebrogenic disorders.

Upright posture assessment has theoretical as well as practical significance. In practice, we have to assess posture in order to have an objective monitoring of the habit of upright posture, to classify pupils when assigning them to remedial physical training programs, to evaluate the effectiveness of the remedial physical training programs and to differentiate upright posture from deviations. Anthropometrical methods used for the assessment of monitoring of general growth and development of children are not fully sufficient for posture assessment. Ideal posture appears rarely and the transition between upright posture and defective posture, as pointed out by Novotná and Kohlíková (2000), is smooth and often hard to define.

Teachers, trainers, occupational therapy assistants, etc. need to know, at least in general, what is the state of postural and phasic muscles involved in keeping posture correct.

To be able to find the results of our posture improvement activities, we have to assess the initial state of the child's posture expressed if possible in exact numbers.

Lots of various methods have been developed to measure the quality of posture keeping: siluetographic, photographic, X-ray pictures, plaster casts, pantographic methods (tracing the body silhouette with appropriate reduction on a paper), goniometric methods (using goniometers with gravitation protractors).

Many examinations make use of instruments, but it is not always easy to carry them out in usual school practice or remedial physical training programs. Therefore we are satisfied with these practical and most often used simple methods based on visual observations – somatoscopic methods – assessment of posture, general body build and individual body parts, plus the shape of the spine and foot arch.

METHODS

This study is a result of a research project which forms a part of the Research Framework MSM 154100020 "Research on the Somatic and Psychological State of the Czech Population with Applications in Anthropagogy, Pedagogical Psychology, Clinical Anthropology and Ergonomics" for the period 1999–2003, carried out by the Department of Anthropology and Hygiene of the Pedagogical Faculty of Palacký University, Olomouc.

Within the transversal anthropological survey at seven primary schools of the Olomouc region in the period 2001–2002, the assessment of posture and foot arches was carried out on 1201 probands (621 boys and 580 girls) aged 7 to 15 years. For technical reasons, we chose the Jaroš and Lomíček (1957) somatoscopic method of posture assessment based on the evaluation of individual body parts, which is also recommended as the most suitable by Přidalová (1997) who carried out her own survey of children in Olomouc, as well as by Vařeková and Vařeka (1995).

This method is easy, not time consuming, cheap, workable, with relatively maximum accuracy – i.e. results with minimum errors. Assessment is focused on the following body parts: head and neck posture, thorax posture, abdomen posture with pelvis inclination, curve of the back, posture in the frontal plane, and assessment of the lower limbs. Each assessed body part was evaluated with a mark from 1 to 4. The foot arch state diagnostics were carried out using plantograms in accordance with the Klementa (1987) method. As a part of the survey, the examined children answered a questionnaire on their life style that brought information on back pain during the day and pain in the area of the spine where it occurs most often.

For numeric processing of the results of posture evaluation and the questionnaire, we used mathematical statistics methods and Statgraphics Version 5 software. The statistical level of significance, so called Pearson's correlation coefficient, was used to find out the relationship between the age and the posture of probands in particular age groups. The testing was on the 0.05 significance level.

RESULTS AND DICUSSION

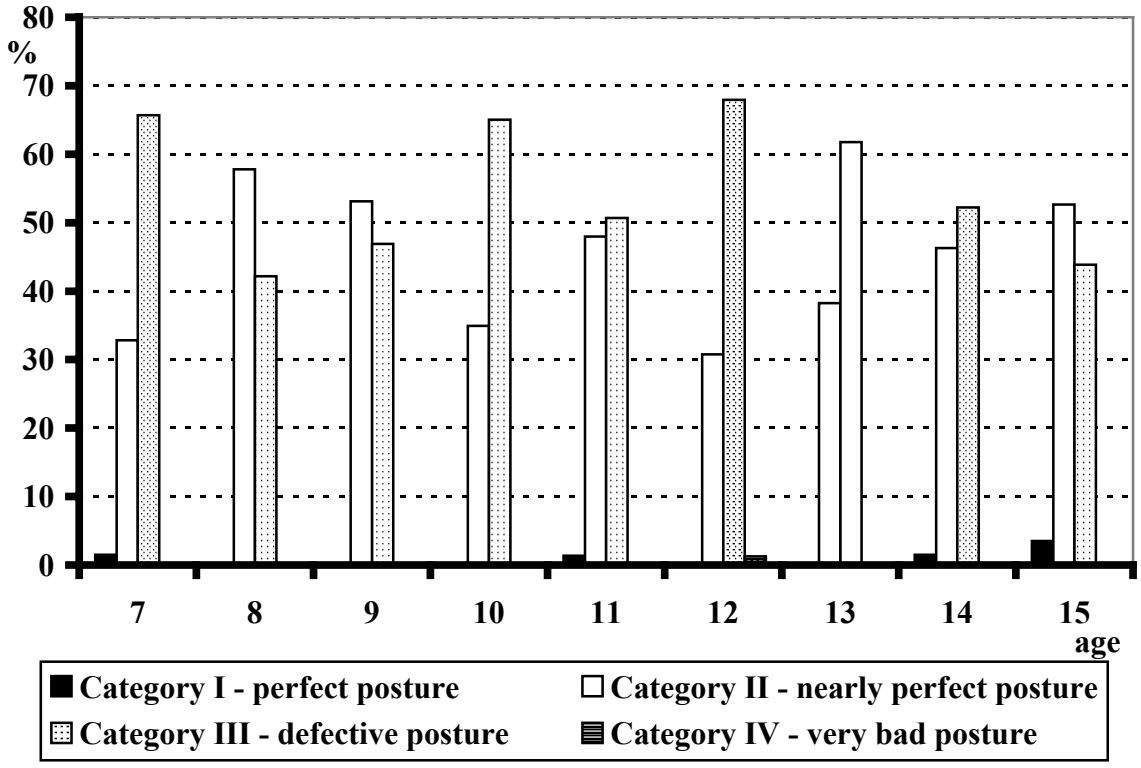
The results of the posture assessment of boys and girls of school age, as for distribution and percentage of occurrence, do not imply a positive trend (TABLE 1, 2 and Fig. 1, 2). For both sexes of all age groups, perfect posture occurs only sporadically. Perfect posture was only found in 5 boys and 6 girls. Very bad posture was not found in girls, only in one twelve-year old boy. The most frequent categories are: II – nearly perfect posture and III – defective posture.

From the results, the inter-sexual differences between the posture of boys and girls are obvious (TABLE 1, 2). Girls of all age groups have better posture than boys of the same age. In category II – nearly perfect posture, there are 43.16% boys and 62.07% girls. In category III – defective posture, the relationship is inverse – 56% boys and 36.90% girls. The achieved results are in cor-

TABLE 1
Boys' posture within individual age groups

Age	n	Category I perfect posture		Category II nearly perfect posture		Category III defective posture		Category IV very bad posture	
		n	%	n	%	n	%	n	%
7	**67**	1	1.49	22	32.84	44	65.67	0	0
8	**64**	0	0	37	57.81	27	42.19	0	0
9	**64**	0	0	34	53.12	30	46.88	0	0
10	**83**	0	0	29	34.94	54	65.06	0	0
11	**73**	1	1.37	35	47.95	37	50.68	0	0
12	**78**	0	0	24	30.77	53	67.95	1	1.28
13	**68**	0	0	26	38.24	42	61.76	0	0
14	**67**	1	1.49	31	46.27	35	52.24	0	0
15	**57**	2	3.51	30	52.63	25	43.86	0	0
Total	**621**	**5**	**0.80**	**268**	**43.16**	**347**	**55.88**	**1**	**0.16**

Fig. 1
Boys' posture within individual age groups



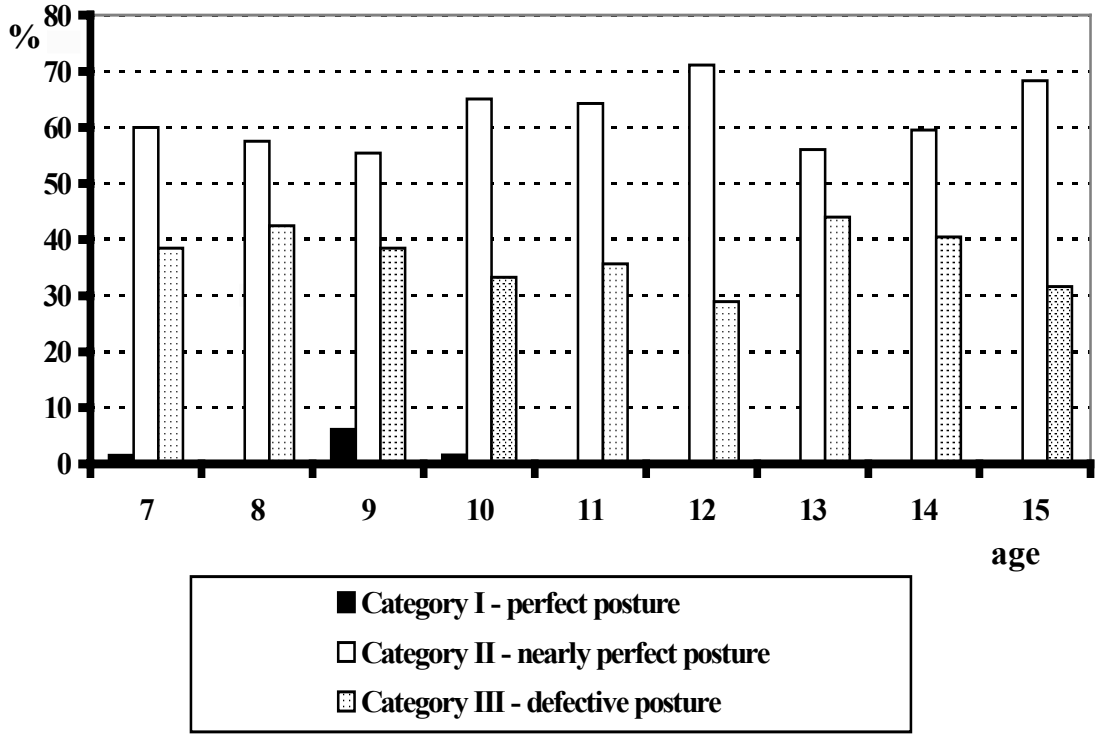
relation with data presented by Riegerová et al. (1993), Štěpnička (1976), Kristiníková and Dobešová (1998). Riegerová et al. (1993) states the results of a posture survey of pupils aged 10 to 14 years within the semi-longitudinal research carried out at Olomouc schools in the period 1985 to 1990.

Following posture assessment in accordance with the Jaroš and Lomíček method (1957), only one proband was ranked within the category I – perfect posture, one quarter of the probands (26.4%) came under category II – nearly perfect posture and defective posture was found in nearly three quarters of the set (72.7%). Štěpnička

TABLE 2
Girls' posture within individual age groups

Age	n	Category I perfect posture		Category II nearly perfect posture		Category III defective posture		Category IV very bad posture	
		n	%	n	%	n	%	n	%
7	**65**	1	1.54	39	60	25	38.46	0	0
8	**73**	0	0	42	57.53	31	42.47	0	0
9	**65**	4	6.15	36	55.38	25	38.47	0	0
10	**63**	1	1.59	41	65.08	21	33.33	0	0
11	**70**	0	0	45	64.28	25	35.72	0	0
12	**76**	0	0	54	71.10	22	28.90	0	0
13	**66**	0	0	37	56.04	29	43.96	0	0
14	**42**	0	0	25	59.52	17	40.48	0	0
15	**60**	0	0	41	68.33	19	31.67	0	0
Total	**580**	**6**	**1.03**	**360**	**62.07**	**214**	**36.90**	**0**	**0**

Fig. 2
Girls' posture within individual age groups



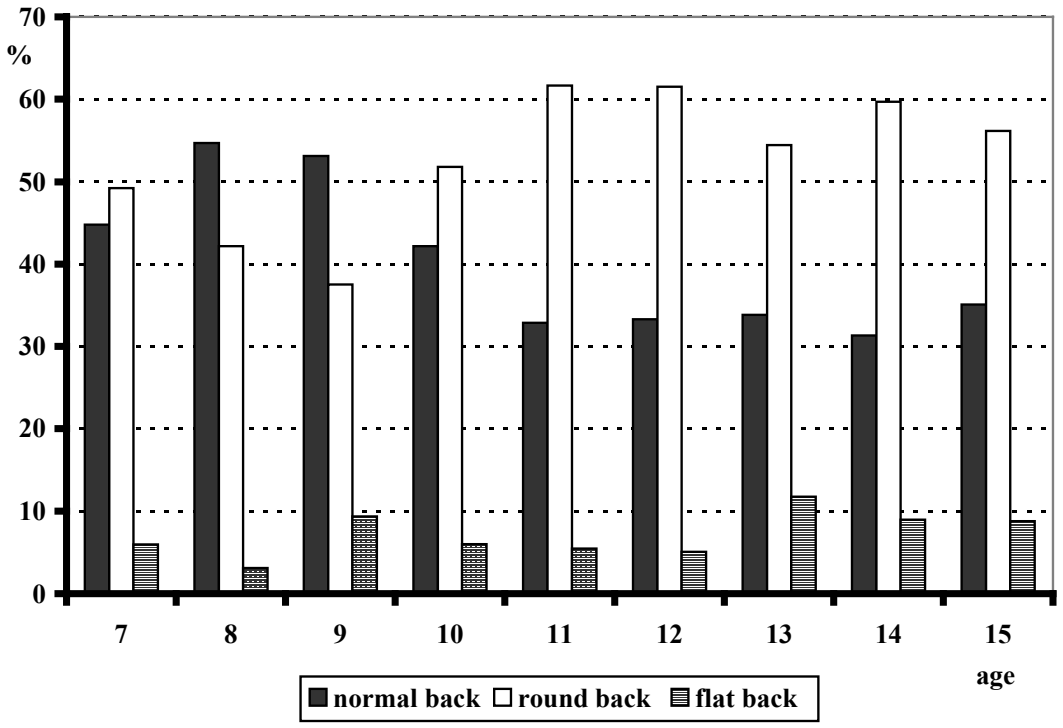
(1976) in his representative set found out that no boy and only 2% of the girls came under category I, 41% of the boys and 48% of the girls in category II – nearly perfect posture, 53% of the boys and 46% of the girls in category III – defective posture, and 6% of the boys and 5% of the girls came under category IV – very bad posture. Very bad posture was not found in any pupil and the inter-sexual difference implied slightly better posture in girls. Kristiníková and Dobešová (1998) found in the same age groups that nearly 60% of the boys had defective posture and boys had worse posture in comparison with girls.

On the contrary, it does not support the results presented by Přidalová (1997), who evaluated posture in Olomouc children aged 6–10 years. Přidalová (1997) found better posture in boys in all measured categories in comparison with girls. An unfavorable development regarding the state of posture is also found by

TABLE 3
Evaluation of the curve of the back in boys and girls in particular age groups

Age	Curve of the back in boys						Curve of the back in girls					
	normal		round		flat		normal		round		flat	
	n	%	n	%	n	%	n	%	n	%	n	%
7	30	44.78	33	49.25	4	5.97	12	18.46	49	75.38	4	6.15
8	35	54.69	27	42.19	2	3.12	10	13.70	54	73.97	9	12.33
9	34	53.14	24	37.51	6	9.35	14	21.54	43	66.15	8	12.31
10	35	42.17	43	51.81	5	6.02	7	11.11	50	79.37	6	9.52
11	24	32.88	45	61.64	4	5.48	8	11.43	49	70	13	18.57
12	26	33.3	48	61.5	4	5.1	15	19.73	55	72.37	6	7.90
13	23	33.82	37	54.42	8	11.76	7	10.61	50	75.76	9	13.63
14	21	31.34	40	59.70	6	8.95	5	11.91	35	83.33	2	4.76
15	20	35.09	32	56.14	5	8.77	6	10	49	81.70	5	8.30
Total	**248**	**39.92**	**329**	**52.98**	**44**	**7.1**	**84**	**14.48**	**434**	**74.82**	**62**	**10.69**

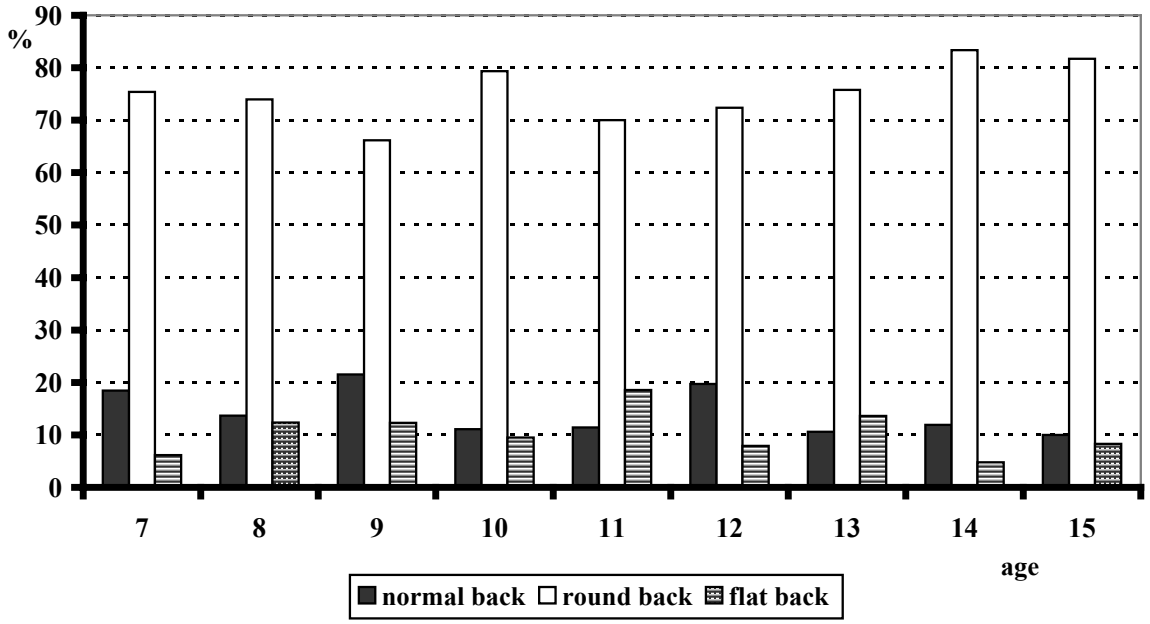
Fig. 3
The curve of the back in boys in particular age groups



Liba (2000) and Jankovská (1998). Following the results of posture assessment of Slovak children, they found out that 30% of children rank within "perfect" and "very good posture" categories, 59% fell under defective posture and very bad posture was found in 12% of the examined children. The main cause of this trend is, besides endogenous reasons, especially the lack of movement and one-sided loading of the organism.

Comparing the individual age groups of boys and girls, their posture obviously does not depend on their age. The distribution and percentage of defective posture has a sinuate shape in both sexes within the age span of 7–15 years. In boys, the lowest percentual occurrence was found in the age group of 8 year-old boys, i.e. 42%, and the highest percentage of boys with defective posture of the whole set, i.e. 68% of cases, have been found in boys of 12. In girls, the occurrence of defective

Fig. 4
The curve of the back in girls in particular age groups



posture varies from 29% at 12 years of age to the highest percentage found at the age of 13 with 44% of girls.

For more detailed information on the relationship between age and posture, the statistical level of significance was analyzed using the Pearson's correlation coefficient to find out the relationship between the dependence between the two quantities. Testing was carried out at the statistical level of significance of 0.05. The calculated correlation coefficient, used for testing each age group of a certain sex in relationship to particular posture categories, did not confirm a significant relationship between the age group and the posture category. Posture in boys and girls within this age rank probably does not depend on age.

When examining posture, we also evaluated the posture of individual body parts in sagittal and frontal planes. In the sagittal plane, the thorax spine arch was evaluated within three levels: the spine is slightly kyphotic = normal back, the spine shows slight deviations and significant bending in this part = round back (this group includes probands whose curve of the back within the thorax part is evaluated by the degree of 2, 3 or 4 in accordance with the Jaroš & Lomíček method), and with a lack of normal curve = flat back. The assessment of the thorax spine curve is shown in TABLE 3 and Fig. 3, 4.

The high percentage of round backs found in nearly 53% of boys and 75% of girls imply the occurrence of muscular dysbalances in this area that is called "upper cross syndrome" in the literature. Janda (1982) describes this syndrome as a typical occurrence of muscular dysbalances between the shortened postural muscles on the front side of the thorax (major pectoral and minor pectoral muscles), and on the rear side of the thorax, the slackened phasic muscles, namely shoulder blade muscles (trapezius, rhomboid muscles), back muscles and trunk erectors and also between deep neck flexors on one side and neck extensors on the other side. These results in keeping the head forward, keeping shoulders raised and stuck forward and the abduction locomotive stereotype in the shoulder joint is negatively affected. To a certain extent, this fact is supported by the finding of outstanding shoulder blades as a consequence of the above-mentioned slackening of shoulder blade muscles that was found in 84% of boys and 67.4% of girls.

The high percentage of round backs in girls is caused by a kind of shyness connected with the period of adolescence and the growth of breasts, which is evidenced by a gradual increase in the occurrence of round backs in girls within the age group of 12 to 15 years.

The assessment of the curve of the back in the sagittal plane using the tangent let fall from protuberantia occipitalis shows the depth of the bend in the area of the cervical and lumbar lordosis. In probands not ranked within the category I – perfect posture, the depth of the cervical and lumbar lordosis varied within the limits stated by Srdečný et al. (1982) and Kryštofič (2000). In this category, the cervical lordosis varied within 2.5–3 cm and the lumbar lordosis within 3–3.5 cm. Probands ranked within the category II – nearly perfect posture and had an average depth of cervical and lumbar lordosis within 4 to 5 cm. The largest depth of the cervical and lumbar lordosis was found in category III – defective posture. For both sexes, the average depth

of the cervical lordosis varied from 4.5 to 6 cm, and the value of lumbar lordosis between 5 and 7 cm.

The deeper lumbar bend was often accompanied by a significant pelvis ventral flexion. According to Janda (1982), it is a muscular dysbalance called the lower cross syndrome. It is a combination of weakened gluteus and slackened abdominal and shortening of coax flexors, lumbar spine extensors and lumbar quadrangular muscle (m. quadratus lumborum). This syndrome causes impairment of the mechanism of the trunk's motion when sitting up from a lying position and when straightening up from a forward bend. Janda (1982) states that this results in a higher inclination of the pelvis, a bent abdomen and lumbar hyperlordosis.

The measured depths of cervical lordosis in category II – nearly perfect posture and especially in category III – defective posture do not meet physiological standards. In this case, it is not possible to speak about the depth of the bend in the cervical as the head is kept stuck forward (non-physiological position of the head in relation to the trunk) from the median and therefore the distance of the cervical bent from the median is very large. Muscular dysbalances in this area are accompanied with higher stress in the area of the beck of the neck, an impairment of the stereotype of cervical flexion. As stated by Janda (1982), this muscular dysbalance that he calls the upper cross syndrome is caused by shortened cervical muscles (namely upper trapezius, deep cervical muscles), slackened phasic muscles on the front side of the neck (deep flexor muscles), or the occipital nuchal muscles can be also shortened.

On the frontal plane, attention was focused on the equal height of shoulders and blades, symmetry of hips and thorax-abdominal triangles, the spinal curve, its lateral deviation and its bent in the cervical and lumbar areas. Assessment of the posture of the back was finished by evaluation of the deep forward bent, when the symmetry of the profile of paravertebral muscle groups and the torsion of the spine while bending forward were examined. Following complex assessment of all these symptoms, an evaluation of scoliotic posture was performed (TABLE 4 and Fig. 5, 6).

Srdečný et al. (1982) and Kubát (1993) characterize scoliotic posture as the lateral deflection of the spine on the frontal plane to one and immediately to the other side. Rychlíková (1985) ranks scoliotic posture among the essential disorders of posture. According to Kubát (1993) and Čermák, Chválová, Botlíková, and Dvořáková (2000), it is a deviation of a purely functional nature, as no pathological changes of the shape or position of the vertebrae can be found on the X-ray picture of scoliotic posture and it is not a real deformity of the spine. This defect is caused by uneven tiredness resistance, unilateral slackening of muscles in individual parts of the spine, asymmetry of paravertebral muscles loading, bad sitting habits when reading or writing, one-sided workload or sport activities. Scoliotic posture is a kind of functional disorder that can be improved or totally removed by active muscle exercises.

Scoliotic posture is diagnosed when the above-mentioned symptoms are found as stated by Škvára and Srdečný (1969), Srdečný et al. (1982), Čermák and Strnad (1976), and Tichý (2000).

The high occurrence of this physical handicap is surprising. Scoliotic posture was found in 428 boys, i.e. 68.9% of the total number of 621, and in 359 girls, i.e. 61.9% of the total number of 580 female probands.

TABLE 4
Occurrence of scoliotic posture in boys and girls

Age	Scoliotic posture in boys					Scoliotic posture in girls				
	n	yes		no		n	yes		no	
		n	%	n	%		n	%	n	%
7	67	49	7313	18	26.87	65	40	61.54	25	38.46
8	64	47	73.44	17	26.56	73	49	67.12	24	32.88
9	64	37	57.81	27	42.19	65	40	61.54	25	38.46
10	83	58	69.88	25	30.12	63	44	69.84	19	30.16
11	73	53	72.60	20	27.40	70	43	61.43	27	38.57
12	78	51	65.40	27	34.60	76	45	59.20	31	40.8
13	68	50	73.53	18	26.47	66	42	63.64	24	36.36
14	67	45	67.16	22	32.84	42	23	54.76	19	45.24
15	57	38	66.67	19	33.33	60	33	55	27	45
Total	**621**	**428**	**68.92**	**193**	**31.08**	**580**	**359**	**61.90**	**221**	**38.10**

Fig. 5
Occurrence of scoliotic posture in boys

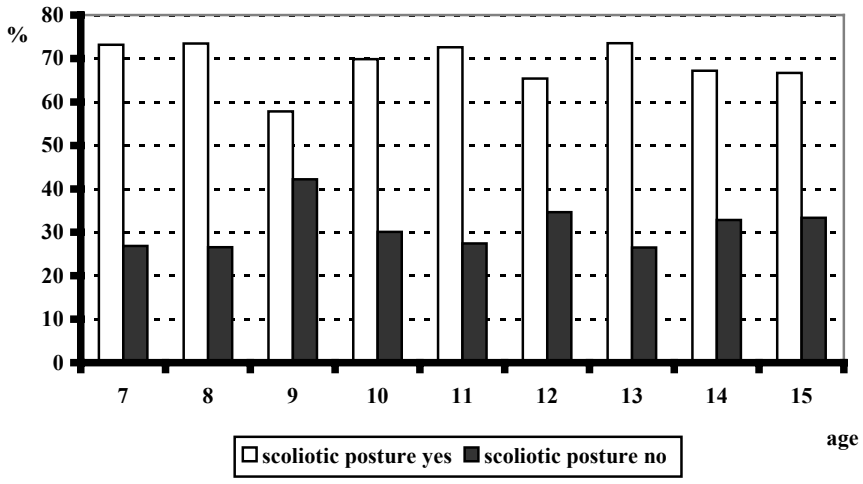
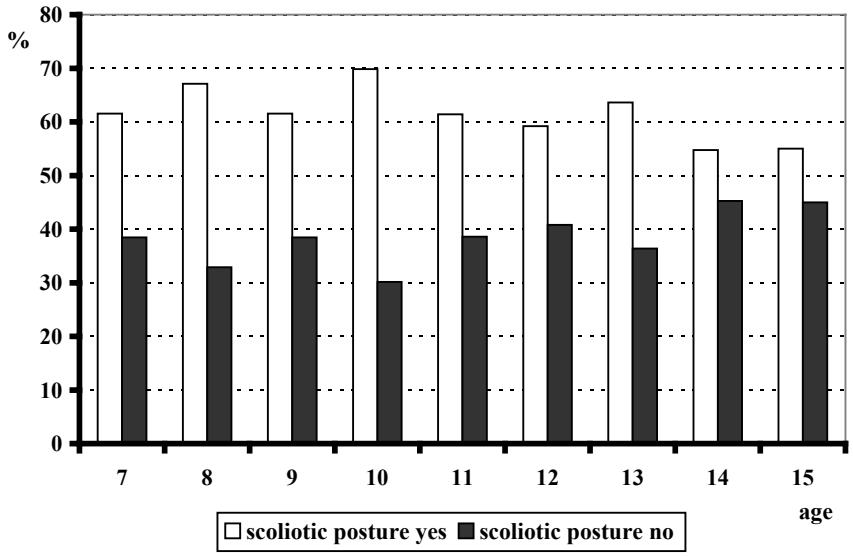


Fig. 6
Occurrence of scoliotic posture in girls



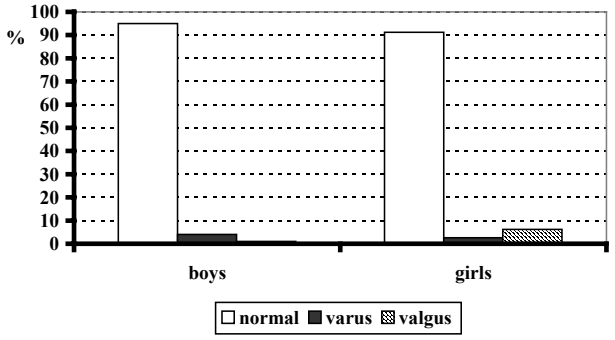
The slightly decreasing occurrence of scoliotic posture is obvious from 7 to 15 years, with the deepest drop between 14 and 15 years of age (TABLE 4 and Fig. 5, 6). It may be caused by the fact that back and abdomen muscles of the muscle corset get stronger in the adolescence period. Scoliotic posture symptoms in some probands were so significant that we could diagnose idiopathic scoliosis.

Rychlíková (1997), Lewit (1996), Novotná and Kohlíková (2000) characterize scoliosis as a deflection of the spine on the frontal plane caused by the rotation of vertebrae around their longitudinal axes when the stress changes result in their deformation and structural changes. Unlike scoliotic posture, scoliosis cannot be removed by active muscle exercises. Probands with a suspected occurrence of scoliosis received a recommendation to go see the orthopedics specialist. It is surprising that probands with apparent symptoms of scoliosis had not been to see orthopedics specialists, their parents did not show any concern nor did they even notice that their child did not have correct posture and even did not know about this possible defect at all. By way of illustration, in 81% of boys, uneven height of shoulders was found (right shoulder higher in 45.8%, left shoulder higher in 35.1% of boys), in girls the asymmetry of shoulders was found in 72.1% of evaluated

TABLE 5
Lower limbs assessment in boys and girls

	Lower limbs					
	Normal		Varus		Valgus	
	n	%	n	%	n	%
Boys	590	95.00	25	4.00	6	1.00
Girls	529	91.20	15	2.59	36	6.21

Fig. 7
Lower limbs assessment in boys and girls



probands (right shoulder higher in 38%, left shoulder higher in 34.1% of girls).

In probands with scoliotic posture, the uneven height of the paravertebral muscle groups occurred regularly; the muscles were unevenly dislocated at the both sides of the spine, when a boy or a girl gradually bent forward and then unbent from a deep forward bend. The forward bend or following unbending was frequently accompanied with turning the trunk to the side.

Scoliotic posture was found in all probands with a flat back, where the physiological spine bend was not apparent. A flat back was found in 44 boys, i.e. 7.1% and in 62 girls, i.e. 10.7% of the sample. A flat back appeared especially in asthenic probands with general muscle slackness.

The flat back, as stated by Srdečný et al. (1982), respectively flat spine, has lower resistance against higher loads. The flat spine efforts to balance the load exerted on it and this can result in lateral deflection. Srdečný et al. (1982) attracts attention to the dangerous combination of a flat back and scoliotic posture as the lowest degree of scoliosis, i.e. a serious defect manifesting itself in changes of structure, rotation and the shape of vertebrae and their deformities.

The last area of posture assessment in accordance with the Jaroš and Lomíček method (1957) is the evaluation of the lower limbs. Unlike the previous areas, this evaluation brings much better results. Normal posture of lower limbs was found in 590 (95%) boys and 529 (91.2%) girls. Valgus posture of limbs was found in 1% of boys and 6.21% of girls. Varus posture of limbs occurred in 4% of boys and 2.59% of girls (TABLE 5 and Fig. 7).

Together with the posture assessment, the foot arch was evaluated in accordance with the method stated by Klementa (1987). The results imply that in boys, a normal foot arch occurs in the right foot in 84.4% and in the left foot in 84.3% of probands, flat foot occurs in the right foot in 10.1% of cases and in the left foot in 7.5% of the cases and a high foot arch was found in the right foot in 5.5% and in the left foot in 8.2% of boys. In girls, a normal foot arch was found in the right foot in 85.5% and in the left foot in 84.4% of girls. In comparison with boys, girls had a lower number of flat feet, 2.8% in the right foot and 3.3% in the left foot, and a higher number in the high foot arch, 11.7% in the right foot and 12.3% in the left foot.

In the questionnaire asking about the health condition of the spine, the question "Does your back hurt during the day?" was answered "Yes" by 5.7% of the boys and by 9.5% of the girls. Occasional pain occurs in 30.3% of the boys and in 42.8% of the girls. The second question, "In which part of the spine does the pain occur most often?", was answered "cervical spine" by 10% of the boys and 18.9% of the girls, "thorax spine" by 11.5% of the boys and 13.3% of the girls and "lumbar spine" by 18.7% of the boys and 19.1% of the girls.

Generally, the above results of the posture assessment of Olomouc boys and girls confirm an unfavourable trend. The assessment results imply that 57% of boys and 37% of girls with defective posture should attend some remedial training programs. However, such a remedial training program is not offered at any of the seven schools where the survey was carried out, which is a very surprising finding.

CONCLUSION

The above results and the presented data from literature suggest that the occurrence of defective posture is very high in the present-day school age population. The assessment results imply that:

1. Defective posture appears in 57% of boys and 37% of girls in the age group 7–15 years.
2. The main reason for the defective posture is muscular dysbalance, the so-called upper cross syndrome and lower cross syndrome manifested in keeping the head stuck forward, a round back, outstanding shoulder blades, high pelvis inclination accompanied with lumbar lordosis, and in many cases with loose abdominal muscles.
3. Scoliotic posture was found in 69% of boys and 62% of girls. A typical example of this functional disease is the uneven height of the shoulders and shoulder blades,

uneven thorax-abdominal triangles, lateral spine curve deflection and unevenness of the paravertebral muscular group profiles.

4. The occurrence of defects in lower limbs is very low. Normal positioning of lower limbs was found in 95% of the boys and 91.2% of the girls. The right foot arch was found in approximately 85% of both boys and girls. Boys had flat foot more often than girls. On the contrary, girls more often had high foot arch than boys.

5. No remedial training program was offered at any of the schools where the survey was carried out, although the occurrence of defective posture is high.

The high occurrence of functional disorders of the locomotive system is alarming. It is necessary to be aware of the fact that defective posture cannot be improved at lessons of physical training or by pupils' activities in their free time, leaving the development of the posture only to natural evolution. This is very unreliable as the children of the present generation tend to hypomobility accompanied by a high intensity of a static physical load in sitting.

However, it is not possible to see only the bad state of things. It is necessary to emphasize that defective posture causes disorders of static and dynamic locomotive stereotypes, which results in overloading of the supportive-locomotive system and its functional disorders that may lead to pain and higher muscular tension, and later even to morphological disorders. Defective posture is not only an aesthetic disorder but also the cause of vertebrogenic difficulties that are the cause of an incapacity to work at the productive age.

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HODNOCENÍ DRŽENÍ TĚLA DĚTÍ MLADŠÍHO A STARŠÍHO ŠKOLNÍHO VĚKU V OLOMOUCKÉM REGIONU

(Souhrn anglického textu)

V rámci antropologického výzkumu byla provedena diagnostika držení těla u 1201 dětí mladšího a staršího školního věku somatoskopickou metodou Jaroše a Lomíčka (1957) a hodnocení klenby nohy technikou plantogramů, kterou uvádí Klementa (1987). Výsledky hodnocení držení těla ukazují na dále pokračující nepříznivý trend funkčních poruch pohybového aparátu u současné populace dětí a mládeže. Vadné držení těla bylo diagnostikováno celkem u 56 % chlapců a 37 % dívek. Hlavní příčinu vadného držení těla autor spatřuje především ve výskytu svalové dysbalance ve smyslu horního a dolního zkříženého syndromu. Stav klenby nohy je poměrně uspokojivý, protože u cca 85 % probandů byla zjištěna normálně klenutá noha.

Klíčová slova: mladší a starší školní věk, držení těla, somatoskopická metoda, vadné držení těla, svalové dysbalance, klenba nohy, olomoucký region.

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First-line publication

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PHYSICAL PROFILE IN YOUNG CROSS-COUNTRY SKIERS FROM 10 TO 16 YEARS OLD

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Submitted in April, 2004

Body composition, i.e. relative and absolute amount of body fat and fat free mass (FFM) is a significant physical sign, which is developed in consequence with age, physical maturation level and gender. The aim of this study was to assess physical profile in young cross-country skiers with the emphasis on assessment of basic anthropometric parameters, i.e. body weight, height, BMI and somatotype. The partial objective was to compare skinfold thickness (SKF) measurement and bioelectric impedance analysis (BIA) as methods for body composition determination, especially to compare predictive equations used to find the relative amount of body fat calculation. Altogether subjects were tested n = 34 aged 10 to 16 years, 21 of whom were boys and 13 of whom were girls. Comparison of selected predictive equations point to the significant differences between various methods.

Keywords: Body composition, skinfold thickness (SKF) measurement, bioelectric impedance analysis (BIA).

INTRODUCTION

Monitoring different physical characteristics in children and adults is the simplest way to classify physical profiles of individuals and the general population. An optimum body weight in relation to performance and health is affected by age, gender, physical activity and sport, somatotype, heredity and variability of individuals. There are a number of indexes, that set the optimum body weight range in relation to health and sport performance. However, using some of them is limited. There are the graphs of weight/height ratio, which can be used for the evaluation of individual growth in children and for prediction of body weight in a range of the population.

We don't manage with an estimate of body weight and derived indexes under clinical conditions, but the assessment of body fatness and other components of body composition is necessary (Bunc, 1998a, 1998b).

Body composition is one of the most important characteristics of the development level during human ontogeny, health status, physical fitness and performance, nutrition and dietary intake (Pařízková, 1998, 1). Body composition, i.e. the relative and absolute amount of body fat and fat free mass (FFM) is a significant physical sign, which is developed in consequence with age, physical maturation level and gender. Changes in body component ratios are important for the assessment of evolutionary trends in body composition. Body composition and other changes connected with maturation are affected significantly by environmental factors. Nutrition, health status, physical activity and life motion experience are additional factors influencing body composition (Pařízková, 1977, 1998). A series of factors, especially heredity premises, nutrition habits, physical activity and metabolism levels in the body and their interaction result in body weight increase. The amount of body fat changes in the course of individual ontogeny. Gender differences in body fat distribution occur in childhood, amplify in adolescence and continue in adulthood. Body weight and the amount of body fat of most people increase during their lifetime. The type of fat distribution is among the important ethnic and racial characteristics (Riegerová, 1998).

The aim of this study was to assess physical profiles in young cross-country skiers with the emphasis on assessment of basic anthropometric parameters, i.e. body weight, height, BMI and somatotype. The partial objective was to compare skinfold thickness (SKF) measurement and bioelectric impedance analysis (BIA) as methods for body composition determination, especially to compare the predictive equations used to determine the relative amount of body fat calculation.

METHODS

The study proceeded in cooperation with the Biomedical Laboratory and Sport Research Centre at Charles University in Prague, Faculty of Physical Education and Sport.

The followed group includes young cross-country skiers (n = 34, 21 boys, 13 girls, age: 10–16 years) the pupils of a Sport elementary school with a focus on cross-country skiing (ZŠ T.G.M. Vimperk) and at the same time the

members of cross-country skiing clubs LIPT and SOSY. Reference standards in percentile graphs created for Czech boys and girls aged from birth to 18 years (Bláha et al., 1994, 1998) were used for body height, weight and weight/height ratio (BMI) evaluation. Somatotypes were set in terms of anthropometric parameters. We used SURVEY version 2.95 software (http://www.med.muni.cz/prelek/survey/servey.html). Skinfold thickness measurement (SKF) and bioelectric impedance analysis (BIA) were used for body composition or the determination of the relative amount of body fat. We measured the skinfold thickness on defined sites of the right side of the body using Best's caliper, by Pařízková (1977, 38). Best's caliper exerts a constant pressure on the measured skinfold and transmits it to contact terminals (3 mm in diameter, circular shape) by means of a spring calibrated for a constant pressure of 200 g (i.e. cca 28 g/mm^2). The apparatus Bodystat 500 (whole-body monofrequency impedance with tetrapolar configuration of electrodes) was used for bioelectric impedance assessment. We used the predictive equations for boys and girls by Pařízková (1977, 38), by GAUK (Bunc et al., 1998, 1), by software Antropos 2.3 (1995) to calculate the relative amount of body fat.

RESULTS

The average values of anthropometric parameters in young cross-country skiers are reported in TABLE 1. Altogether subjects were tested n = 34 aged 10 to 16 years, 21 of whom were boys and 13 of whom were girls.

TABLE 1
Anthropometric parameters in cross-country skiers

	Boys (n = 21)	Girls (n = 13)
Age (years)	13.2 ± 1.9	13.2 ± 1.0
Body height (cm)	162.0 ± 14.9	159.6 ± 7.2
Body weight (kg)	47.2 ± 13.0	46.4 ± 5.2
BMI (kg.m^{-2})	17.5 ± 1.9	18.2 ± 1.1
Arm circumference relaxed (cm)	21.7 ± 2.5	21.3 ± 0.9
Calf circumference max. (cm)	31.4 ± 3.7	32.3 ± 1.7
Epi hum. (mm)	72.9 ± 10.2	70.4 ± 3.0
Epi fem. (mm)	91.6 ± 7.0	91.2 ± 5.6
Endomorphic component	1.1 ± 0.2	1.6 ± 0.5
Mesomorphic component	3.8 ± 0.8	3.9 ± 0.7
Ectomorphic component	4.5 ± 0.7	4.0 ± 0.8

(data are presented as mean ± SD)

The evaluation of body height by means of percentile graph (Bláha et al., 1994) is shown as follows: height values of 13 boys (i.e. 62% of group) correspond to normal values for the Czech population (values between the 25th and 75th percentile), 5 boys (i.e. 24% of group) had higher height (values between the 75th and 97th percentile), 3 boys (i.e. 14% of group) had lower height (values below the 25th percentile), while height values of 7 girls (i.e. 54% of group) correspond to normal values for Czech population (values between the 25th and 75th percentile), 3 girls (i.e. 23% of group) had higher height (values between the 75th and 97th percentile) and 3 girls (i.e. 23% of group) had lower height (values below the 25th percentile).

We calculated weight/height ratio (BMI) of body weight and height values. The percentile BMI graph makes it possible to follow up the trend of this index in relation to age from birth to 18 years. It also renders if possible to evaluate whether the actual body weight corresponds to height or is excessive or reduced (Bláha et al., 1998). We found the BMI values as follows: BMI values of 13 boys (i.e. 62% of group) were between the 25th and 75th percentile, BMI is considered average, 8 boys (i.e. 38% of group) had BMI values below the 25th percentile, their body weight was reduced, while BMI values of 10 girls (i.e. 77% of group) were between the 25th and 75th percentile, BMI is considered average, 3 girls (i.e. 23% of group) had BMI values below the 25th percentile, their body weight was reduced.

Somatographs with individual somatotypes of boys and girls is documented in Fig. 1, 2.

The results of body composition determination by means of SKF measurement and BIA methods (various predictive equations) are in TABLE 2.

TABLE 2
Values of BF (%) by means of SKF measurement and BIA methods (mean ± standard deviation, minimal, maximal values)

		BF (%) SKF 1	BF (%) SKF 2	BF (%) BIA 1	BF (%) BIA 2
Boys	mean	9.5	8.4	5.1	6.4
	SD	1.6	1.9	2.3	1.0
	min	5.9	5.5	0.5	4.3
	max	13.4	11.6	8.7	8.1
Girls	mean	12.3	11.5	5.9	20.1
	SD	3.7	2.3	2.0	1.6
	min	6.8	7.1	1.7	16.7
	max	19.6	15.0	9.5	22.7

SKF 1 skinfold thickness measurement
predictive equations by Pařízková (1977)
SKF 2 skinfold thickness measurement
predictive equations by Bunc et al. (1998)
BIA 1 bioelectric impedance analysis (Bodystat 500)
predictive equations by software Antropos 2.3. (1995)
BIA 2 bioelectric impedance analysis (Bodystat 500)
predictive equations by Bunc et al. (1998)

Fig. 1
Somatographs with individual somatotypes of boys

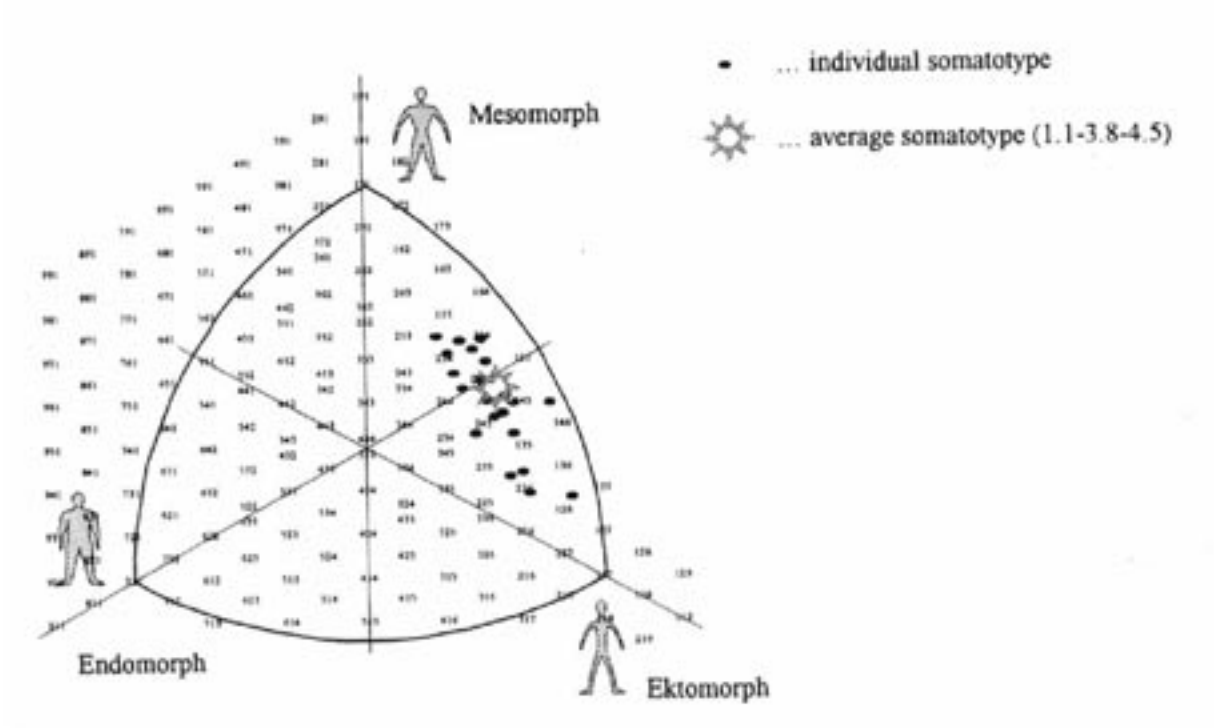

Fig. 2
Somatographs with individual somatotypes of girls

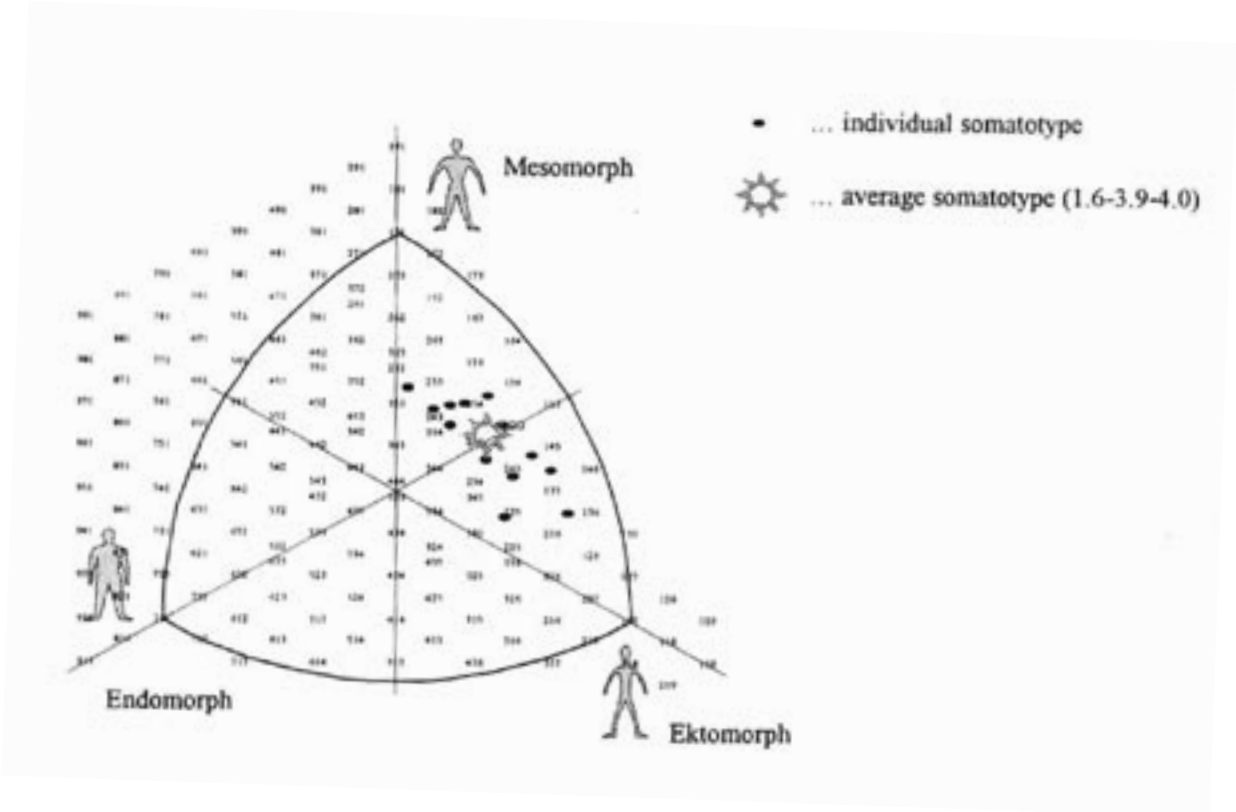

TABLE 3
Correlation (r) and a paired t-test (t) between selected SKF and BIA predictive equations

A) Boys

		SKF 2	BIA 1	BIA 2
SKF 1	r	0.346	-0.054	0.610
	p <	0.01	N.S.	0.01
	t	N.S	N.S.	N.S.
SKF 2	r	0.824		0.279
	p <	0.01		N.S.
	t	0.01		N.S.
BIA 1	r	0.099		
	p <	N.S.		
	t	N.S.		

B) Girls

		SKF 2	BIA 1	BIA 2
SKF1	r	0.755	0.288	0.003
	p <	0.05	N.S.	N.S.
	t	N.S.	0.005	0.05
SKF 2	r	0.497		0.118
	p <	N.S.		N.S.
	t	0.005		0.005
BIA 1	r	0.470		
	p <	N.S.		
	t	0.005		

Correlation analysis was applied to assess the degree of association between SKF measurement and BIA methods, or more precisely between selected predictive equations. A paired t-test was used to identify the differences (TABLE 3).

DISCUSSION

Body composition is the most significant anthropometric parameter in cross-country skiers. Amount of body fat averages 5 to 10% of body weight for males and 16 to 22% of body weight for females (Havlíčková et al., 1993, 107). The best cross-country skiers tend to have the lowest body fat, by Orvanová (1987). Typical percentages of body fat range from about 5 to 12% for elite males and 16 to 22% for elite females (Hoffman, & Clifford, 1992, 8). The boys (age 16.62 ± 1.4 years) had lower amount of body fat (5.2 ± 1.6%), when compared to other groups of boys of comparable age. The girls (age 15.7 ± 1.21 years) had lower levels of body fat (10.6 ± 2.3%), when compared to girls in the normal, untrained population (Pařízková, 1994, 252). It is important to say, that amount of essential lipids ranges about 6% for males and 10% for females. That means some assessed values of body fat (%) from SKF measurement and BIA methods are inadequate. Male cross-country skiers were classified as ectomorphic mesomorphs, while female skiers were characterised as endomorphic mesomorphs (Havlíčková et al., 1993, 107). However, the results of our study are different. For boys mesomorphic ectomorph is predominanted, while for girls mesomorphic ectomorph and ectomorphic mesomorph were mostly found (Fig. 1, 2). The distribution of body fat in children is different from distribution of body fat in adults. Changes of all of three components are affected by many factors, especially growth, type of biological maturation, start of peak height velocity (PHV) (Riegerová, 1998, 61).

Comparison of selected predictive equations point to the significant difference of various methods (TABLE 2, 3). Correlation analysis shows low relation between predictive equations for SKF and BIA methods. The results of paired t-test show nonsignificant difference (< 2%) between the applied predictive equations for boys, while significant difference (> 2%) between the applied predictive equations for girls.

SKF measurement and BIA methods are the most frequent methods for the body composition determination in field conditions. Low price, availability, easy attendance and minimal charge of tested individuals are their priorities. On the other hand both forenamed methods aren't "trouble-free" (Bunc, 1998, 3). The pri-

mary problem of using these indirect methods for body composition assessment is the predictive equations. There are others factors, that can influence the results of measurements (e.g. instrumentation, subject factors, technical skill, environmental factors...). The method of SKF measurement uses to calculation of body fat ratio the specific predictive equations. Total error (biological and technical) range about 3.3% of body fat (Dlouhá, 1998, 8). The accuracy of BIA measurement is influenced by various factors, e.g. errors caused by device handling (cca 3%), method's errors-software (80%, especially predictive equations), hardware – the selected apparatus (cca 1.5%), the type of electrodes (3%), the side of body (1–2%), the selected frequency (1–2%), the hydratation of body (2–4%) and many others (Bunc, 2001, 189).

CONCLUSION

There are various factors, which affect the results of measurement and the assessment of body composition (e.g. technical skill, the selected apparatus, environmental factors...). The primary problem of using the indirect methods for the body composition determination is the predictive equations. DEXA method (dual energy X-ray absorptiometry) is thought as "the gold standard", but because of the high price and technology requirements it is not useful in fields conditions (Bunc, 2001, 189). Research and our study show, that monitoring the thickness of a single skinfold or sum of SKFs (Σ SKF) is optimal for detection of changes in the amount and distribution of subcutaneous fat (Bunc, 2001, 189). There are various apparatus working with the bioelectric impedance principle, but not all of them found the corresponding values. The results of bioelectric analysis are affected by the selected predictive equations. It is to accent, that the measurement should be made by a skilled person to reduce the human factor. The single methods measure the other physical quantity, therefore we can't confuse the results of the single methods. At the conclusion it is to accent too, that it is important to use the same selected method for the body composition determination during the longitudinal monitoring of individuals.

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TĚLESNÝ PROFIL LYŽAŘŮ BĚŽCŮ VE VĚKU 10–16 LET

(Souhrn anglického textu)

Sledování hodnot různých tělesných charakteristik dětí a mládeže je nejjednodušším způsobem hodnocení tělesného profilu jedince či skupiny populace. Tělesné složení, tj. velikost podílu aktivní tělesné hmoty a depotního tuku, vytváří výrazný somatický znak, který se charakteristicky rozvíjí v závislosti na věku, stupni tělesného rozvoje a pohlaví. Cílem této studie bylo zhodnotit tělesný profil u skupiny lyžařů, žáků sportovních tříd se zaměřením na běh na lyžích, s důrazem na hodnocení základních antropometrických charakteristik, tj. tělesné hmotnosti, tělesné výšky, BMI a somatotypu. Dílčím cílem bylo porovnání kaliperace a bioimpedance jako metod pro stanovení tělesného složení, resp. po-

rovnání predikčních rovnic používaných pro konečný přepočet na procento tělesného tuku. Do studie bylo zahrnuto celkem 34 probandů ve věku 10–16 let, z toho 21 chlapců a 13 děvčat. Z výsledků je patrné, že u převážné většiny probandů tělesná výška a hmotnost odpovídají normám populace. Při srovnání jednotlivých predikčních rovnic pro přepočet procenta tělesného tuku je patrná značná odlišnost jednotlivých metodik. Korelační analýza ukazuje převážně na nízkou závislost mezi predikčními rovnicemi pro kaliperaci a BIA. Z výsledků t-testu vyplývá, že u chlapců byl z hlediska významnosti zaznamenán převážně statisticky i věcně (< 2 %) nevýznamný rozdíl mezi použitými predikčními rovnicemi, naopak u děvčat byl rozdíl v použitých rovnicích statisticky i věcně významný.

Klíčová slova: složení těla, měření tloušťky kožních řas, bioimpedance.

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EVALUATION OF MUSCLE FUNCTIONS IN ATHLETES PERFORMING CLIMBING AND JUDO

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In two groups of athletes performing climbing and judo, belonging to the Juvenis, Adultus and Maturus 1 age groups, we conducted an analysis of muscle function and motor stereotypes. On average, the climbers had achieved the VIIth level of difficulty (a good climbing level), the judoists had been doing judo at the 2nd league level. The low, almost zero, finding of shortening and substitutions in climbers gave us the idea of the evocation of an evolutionarily old, early coded model of reflexive motorics during climbing. With the group of judoists, tendency was seen which is known even in other sports, confirming the insufficient compensation of both the unilateral training load and lifestyle.

Keywords: Muscle functions, motor stereotypes, free climbing, judo.

INTRODUCTION

In 2002 we conducted examinations for muscle functions and motor stereotypes on two groups of athletes who did climbing and judo. Members of both groups came from the Moravian region. The group of climbers comprised 36 men ranging in age between 20 and 25 (Adultus) and 3 men between the ages of 35–38 years (Maturus I).

TABLE 1 shows the performance scale of the climbers. It is scaled according to the level of difficulty of individual climbing paths – from the easiest (I) to the most difficult path (XI). The highlighted section indicates the interval between individual levels reached by the athletes. Level VII, the average level of difficulty achieved, represents a group of athletes at a good climbing level. The average performance of older men was between levels IX–X+.

TABLE 1
Performance Scale of Climbers

I II III IV –V V V+ VI– VI VI+ VII– VII VII+ VIII– VIII VIII+
IX– IX IX+ X– X X+ XI– XI

The group of judoists comprised 30 men ranging in age between 15–29 years (Juvenis and Adultus). Their judo skills were on the 2nd league level.

RESULTS

The examination of muscle functions and motor stereotypes was conducted in accordance with the method of Janda 1996, with alternative adjustment of evaluation (Riegerová, 1993). The highly differing examination results of the groups led us to undertake an analytical study on the causes of this situation.

Firstly, the group of climbers: Prior to each training session, it is essential that each climber performs warm up exercises; e.g. Tefelner (1999) which presents some techniques on thorough muscle stretching around the

rhizoid joints, of the trunk musculature and the limbs. For training schedules aimed at children and youth, it is strongly recommended to include additional sports activities, gymnastic exercises and stretching exercises for greater articulation.

Both the body height and weight of climbers were within the limits of standard variations for the average population in the Czech Republic (body height – – 179.3 cm, n.i. = 0.20 s, body weight 73.3 kg, n.i. = = –0.26 s). For comparison with the population standard, we always calculated the weighted average and weighted standard deviations for the relevant age category.

During examination of the postural muscles, we found a comparatively low frequency of shortened muscles even in the age group of Adultus and Maturus.

The most problematic of the muscular region is the bilateral m. trapezius where the shortening occurred in 33.3% and 22.2%. We assume that the conditions and functionality of m. trapezius are considerably influenced by the technique of climbing and belay, and it also reflects the emotional state of the individual. In 22% a shortening of the spinal erector in the lumbar area occurred.

The incidence of muscular shortening was in direct relation to the performance of climbers who have been doing this sport from 1 to 9 years on the levels of difficulty between Vth and IXth (the shorter the climbing time, the greater the extent of muscle shortening for an individual).

With regard to muscles with a predominantly phasic function, a certain debilitation was detected in 19.45% at the m. serratus anterior and mm. rhomboidei (19.45%). Even in this case we assume that this finding is related to the condition of m. trapezius, further of m. latissimus dorsi and is probably conditioned by the length of training and climbing technique.

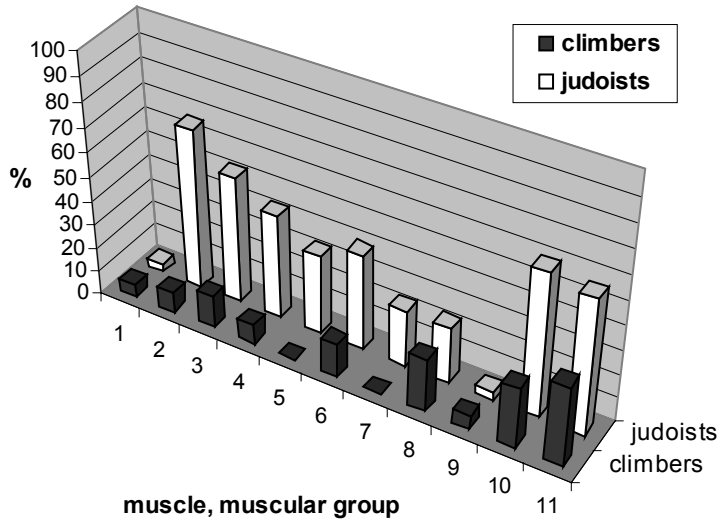
Substitute motor stereotypes were not found, which is surprising with regard to the thus far known high frequencies in childhood, adolescence and in the adult population. Therefore we consider the influence of the mechanism of the evocation of evolutionarily old, early coded models of reflexive motorics. The evolution process of the change of functional involvement of m. gluteus maximus from an abductor muscle to a muscle for extension in the hip joint is connected with habitual bipeds and with morphological adaptation to it.

According to Vojta et al. (1995), reflexive creeping and reflexive turning are congenital global models of motor ontogenesis. During ontogenesis of erection, they became polymorphic, and development ensued.

Free climbing is thus a natural implementation of these basic models in space. The genetically coded locomotor model is, during the learning (training) process, specialized IAW its utilization in sports.

During climbing, the muscle groups of the upper part of the body are most involved, especially the antebrachii. The body of a climber, due to the elevator of the rhizoid joint, moves and thus a high afference is spontaneously activated. During climbing, it is necessary to involve a large range of joint motility to limit levels. A major, actively performed flexion stage of the hip joint is related not only to the flexion but also to the external rotation and abduction of the thigh. Also the adductors go into contraction and, together with the external rotation and femoral abduction, into extension (zero or very low incidence of contraction of these muscles – Fig. 1). Due to contraction of the abdominal

Fig. 1
The frequency of shortening of postural muscles and muscular groups of climbers (n = 36, 1 = 2.78%) and judoists (n = 30, 1 = 3.33%)



1 m. triceps surae dex.
2 knee joint flexors dex.
3 m. rectus femoris dex.
4 m. tensor fasciae latae dex.
5 hip joint adductors dex.
6 m. iliopsoas dex.
7 m. quadratus lumborum dex.
8 m. erector spinae
9 m. pectoralis major dex.
10 m. trapezius sin.
11 m. trapezius dex.

wall, dorsal pelvic flexion is evoked involving the back muscles and the ischiocrural muscles. The bias position of the pelvis on a frontal level is exerted by m. latissimus dorsi and m. quadratus lumborum. The condition of these muscles ranged from very good to excellent.

Three of the tested climbers belonging to the Maturus I (35–38 years) age group have been actively climbing for 17–22 years, with the achieved performance levels of between IX–X+. Shortening of the postural muscles occurred twice at m. trapezius only, muscle shortening only once at m. serratus anterior and mm. rhomboidei. Substitute motor stereotypes were not found again.

In fact, the group of climbers did not complain of subjective pains in individual joint areas, apart from hand joints in 27.78% and knee joints in 16.67%. Pain in the cervical region of the spine was felt by 11.11% of the tested.

Judoists belonging to the Juvenis (15–17 years) age group were below average in both their body height and weight (height 170.23 cm, n.i. = –0.80, weight 58.35 kg, n.i. = –0.86). In adult men (18–23 years) these basic antropometric parameters were within limits of standard variations (weight 180.0 cm, n.i. = 0.21, weight 70.81 kg, n.i. = –0.29), older men (24–29 years) were taller and had above average weight (height 181.25 cm, n.i. = 0.55, weight 89.88 kg, n.i. = 1.24). For judo it is a remarkable advantage to be in the higher weight category because for an individual with these dispositions, it is easier to defend against an opponent who attempts to destabilize his center of gravity.

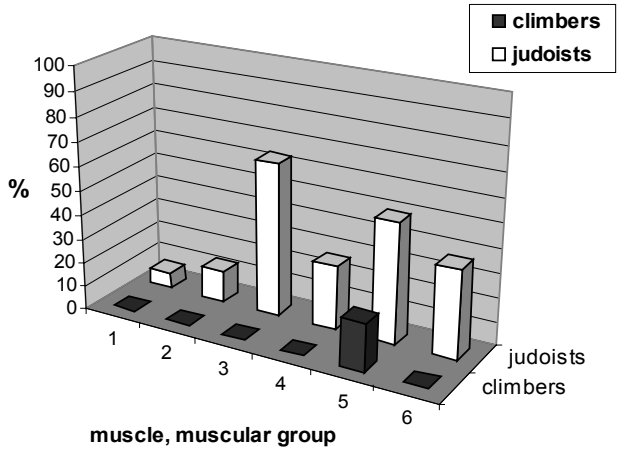
For an assessment of the overall condition of muscle functions, we merged the age categories Juvenis and Adultus into one group.

The resulting situation was significantly worse than in the case of climbers (Fig. 1). The highest frequency of shortening (60% and exceeding 60%) was shown by the knee flexors and decreasing bundles of m. trapezius. Muscle groups securing motions in the hip joint were almost at half strength of the group in the process of shortening, which makes evident the frequent abidance in flexion positions and insufficient compensation in the training process. An incorrect attitude to compensation exercises is generally known. These exercises are often considered by trainers and athletes to be a waste of time. Without any statistical importance of differences, there were only frequency findings of shortening at the m.erector spinae and m.pectoralis major dex.

The established conditions of shortening correspond to the high percentage of substitution motor stereotypes in the area of hip joint, in the sense of primary activation of the hamstrings during extension.

This knowledge can further expand the scope of exercises in health-oriented physical education.

Fig. 2
Frequency of muscle weakness and substitutional motor stereotypes for the group of judoists (n = 30, 1 = 3.33%)



1 nape flexion
2 trunk flexion
3 lower limb extension
4 lower limbs abduction
5 push-up test
6 higher limb abduction

The push-up test manifested the muscle force of the m.serratus anterior and rhombic muscles. Also here only 50% of the test exercise was performed properly. The mm. rhombodei draws the shoulder blade to the spine and pushes it a bit higher. The m. serratus anterior is involved in the protraction and anteversion of the shoulder blade. The m. trapezius is the auxiliary muscle, which has a fixating and rotating effect on the shoulder blade.

A conclusion from the above analysis: One reacts to exogenous and endogenous motor stimuli as in a system. Free climbing evokes evolutionarily old, ontogenetically early motor coded models of reflexive motorics. This, together with the necessity of the application of stretching before each climb, influences positively the motor system of athletes. In young judoists a certain tendency is shown which is true also for other sports (Riegerová, 2002). A unilateral load and neglect of compensations at the very beginning of each training (although in this particular case, several sports clubs in three Moravian cities have been discussed) brings to light health problems and is also a disincentive in achieving a successful sports performance. This knowledge can further expand the scope of exercises in health-oriented physical education.

SUMMARY

In groups of athletes doing free climbing and judo and belonging to the Juvenis, Adultus and Maturus 1 age groups, we conducted an analysis of muscle function and motor stereotypes. On the average, climbers had achieved the VIIth level of difficulty (a good climbing level), the judoists had been doing judo at the 2nd league level.

The low, almost zero, finding of shortening and substitutions in climbers gave us the idea of evocation of an evolutionarily old, early coded model of reflexive motorics during climbing.

Free climbing is the natural implementation of reflexive creeping and reflexive turning in space. The genetically coded locomotor model is, during the learning (training) process, specialized in its utilization in sports.

The incidence of muscular shortening is in direct relation to the performance of climbers, who have been doing this sport from 1 to 9 years at the levels of difficulty between the Vth and IXth (the shorter the climbing time, the greater the extent of muscle shortening for an individual).

The most problematic of the muscular region is the bilateral m. trapezius, where the shortening occurred in 33.3% and 22.2%. In 22% a shortening of the spinal erector in the lumbal area occurred. Substitute motor stereotypes were not found.

With the group of judoists, a tendency was seen which is known even with other sports, confirming insufficient compensation of both the unilateral training load and lifestyle. We noted the resulting high frequency of shortening of the muscle group, securing motions in the hip joint, knee flexors and m. trapezius. The established conditions of shortening correspond to the high percentage of substitution of hamstrings during extension.

This knowledge is worthy of further attention because it can help further expand the scope of exercises in health-oriented physical education.

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HODNOCENÍ SVALOVÝCH FUNKCÍ U SPORTOVCŮ ZABÝVAJÍCÍCH SE VOLNÝM LEZENÍM A JUDEM

(Souhrn anglického textu)

U souboru sportovců zabývajících se volným lezením a judem ve věku Juvenis, Adultus a Maturus 1 jsme provedli rozbor svalových funkcí a pohybových stereotypů. Sportovní lezci dosahovali v průměru VII. výkonnostního stupně (dobrá lezecká úroveň), judisté se judem zabývali na úrovni 2. ligy. Nízký až nulový nález

zkrácení a substitucí u sportovních lezců nás přivedl na myšlenku evokace evolučně starých, raně kódovaných vzorů reflexní motoriky při volném lezení. Volné lezení přestavuje přirozenou realizaci reflexního plazení a reflexního otáčení v prostoru. Geneticky kódovaný lokomoční vzor je pak v procesu učení (tréninku) precizován do sportovního využití. Výskyt svalových zkrácení byl u sledovaného souboru v přímém vztahu k výkonnosti lezců, kteří se tomuto sportu věnovali v rozmezí 1 až 9 let od V. po IX. stupeň obtížnosti (čím kratší doba lezení, tím vyšší počet svalových zkrácení u jednotlivce). Nejproblematičtější svalovou skupinou byl oboustranně m. trapezius (33,3 % a 22,2 %). Ve 22,0 % bylo nalezeno zkrácení vzpřimovače trupu v bederní oblasti. Substituční pohybové stereotypy nalezeny nebyly.

U souboru judistů se projevil trend známý i u ostatních sportů, potvrzující nedostatečnou kompenzaci jednostranného pohybového zatížení i způsob života. Nalezli jsme vysoké procento zkrácení svalových skupin zajišťujících pohyby v kyčelním kloubu, flexorů kolen i m. trapezius. Zjištěnému stavu zkrácení odpovídalo i vysoké procento substitučních pohybových stereotypů v oblasti kyčelního kloubu ve smyslu primární aktivace hamstringů při extenzi.

Tyto poznatky zasluhují další pozornost, nebo mohou rozšířit spektrum cvičení ve zdravotní tělesné výchově.

Klíčová slova: svalové funkce, pohybový stereotyp, volné horolezectví, judo.

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APPLICATION OF THE METHOD OF SPECTRAL ANALYSIS OF HEART RATE VARIABILITY DURING EFFECTS ASSESSMENT OF SELECTED BREATHING TECHNIQUES ON FUNCTIONAL CHANGES IN THE AUTONOMOUS NERVOUS SYSTEM

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Respiration is one of the fundamental factors influencing the actual functional condition of the autonomous nervous system. Our study attempts to clarify the influence of voluntary regulation of the respiratory pattern on the actual functional changes in R-R interval variability. It is closely related to the influence of vagus regulation which can be monitored using the Vario Cardio TF4 diagnostic system and the method of spectral analysis of heart rate variability (SAHRV). In this manner we were able to observe the influence of selective yoga breathing techniques on the frequency and amplitude changes during the observed frequency spectrum of 0.02–0.4 Hz that is related to the activity of the autonomous nervous system. One of the frequency components in this domain is respiratory dependent vagal activity. This frequency and its amplitude markedly stabilise during rhythmisation of respiratory frequency. In respiratory techniques with deeper breathing an increase in total spectral power happens wherein, above all, a frequency component is present which is considered to be respiratory dependent vagus activity. The amplitude of this frequency is modulated by respiratory volume and the inspiratory muscles, whereby the frequency alters by 0.0167 Hz/1 respiratory cycle depending on the respiration rhythm. During a rhythmised respiratory frequency of 12 cycles/min and speed ratio of inspiration to expiration of 2 : 3, our studies observe that this frequency component stabilises in the region of 0.2 Hz.

Keywords: Heart rate variability, autonomous nervous system, regulated/spontaneous respiration, yoga breathing technique.

INTRODUCTION

Human metabolism is related to the input of oxygen, its utilisation inside the body and the subsequent output of carbon dioxide. Respiration is the fundamental physiological function of a living organism and according to Paleček et al. (1999), it encompasses: gas exchange between the external environment and the lungs (ventilation), gas exchange within the lungs (diffusion), gas transport (oxygen, carbon dioxide) between the lungs and tissues, and culminates in the utilisation of oxygen inside the cells.

The respiratory system, according to Paleček (1999), is comprised of bones, joints and chest muscles, the peripheral nerves, relevant structures in the CNS and the chemoreceptors. Breathing accounts partly for the metabolic processes realised by respiration, and partly also for other non-metabolic functions such as participation of breathing in voluntary motor functions such as speech, singing, etc. (Véle, 1997).

Ganong (1999), and similarly Paleček et al. (1999) state that other processes take place in the lungs which are not directly related to breathing: the lungs play an important immunity role, they produce a range of enzymes, DNA, RNA, and prostaglandins. Many substances are also synthesised, degraded and removed during pulmonary blood flow – removal of 25–50% of noradrenalin from the blood during one instance of pulmonary flow, in addition to the significant removal of serotonin. On the surface of the endothelial cells resides an enzyme responsible for transforming angiotensin from angiotensin I to angiotensin II. The total pulmonary metabolic activity is relatively high under the influence of these processes and accounts for nearly 5% of the total resting oxygen expenditure. The lungs also work as an effective sieve that catches, for instance, thromboses travelling upwards from the lower limb veins. Breathing participates in water metabolism. A great proportion of water is exhausted through the lungs; the evaporation of water from within the respiratory system makes possible, to some extent, the maintenance of thermal balance in the body. Rapid absorption of substances also occurs in the lungs – inhalation of toxic substances, inhalation anaesthesia, etc.

According to Paleček (1999, 208) "Ventilation is regulated such that it optimises breathing from the

perspective of survival, minimal energy expenditure, synergism with other systems and in human beings, especially expressively, from the viewpoint of realisation of functions directed by the cerebral cortex".

The maintenance of adequate metabolic levels depending on actual bodily needs is necessary for survival. These actual functional needs of the body are catered to by means of chemical and nervous regulation of respiration. In human beings, a sign of our superiority over other animal species is the ability to perform, to a certain degree, the voluntary regulation of ventilation, or respiratory pattern, which has been developed over generations (Paleček, 1999). The voluntary regulation of respiratory patterns in humans takes place through:

1. regulation of respiratory frequency;
2. regulation of respiratory volume;
3. regulation of the ratio of duration of inspiration and expiration;
4. regulation of respiratory resistance;
5. regulation of inspiratory and expiratory muscle tone.

Regulation of respiration is dependent on external conditions and the functional status of the body, thereby influencing the dynamics of all of the above processes. By the term optimal respiratory pattern Ganong (1999) understands a respiratory pattern where the respiratory effort is minimal. According to Dylevský, Druga, and Mrázková (2000) the respiratory cycle is directed under the command of the respiratory centre in the oblongata. Inspiration is directed by a system of afferent and efferent connections. Fibres of the vagus, fibres of the phrenic nerve, fibres of the spinal nerves innervating the inspiratory muscles, the spinal circuits and the sympathetic and parasympathetic fibres innervating the bronchial muscles constitute the afferent part of the reflex arc.

The ability to voluntarily regulate respiratory pattern in humans is related not only to an autonomous regulation at the level of the oblongata and the brain stem, but also to a certain degree of mutual co-operation between the autonomous and cortical regulatory systems. According to Souček and Kára (2002) voluntary regulation of respiratory pattern influences, through autonomous regulation, among others, changes in blood pressure and heart rate by directly influencing the respiratory centre at the cardio and vasomotor centres located in the brain stem, especially in the oblongata. Apparently, information from receptors in the lung parenchyma and capillaries plays an important role in influencing autonomous regulation. According to Paleček et al. (1999) the cardiovascular system, to some extent, has corporate arterial baroreceptors in common with the respiratory system. According to Souček and Kára (2002) it is by these means that the modulation of blood pressure and heart rate through the direct influence of the respiratory centre on the cardio and vasomotor centres of the brain steam and oblongata occurs during the course of a respiratory cycle. This interaction modulates also the function of arterial and probably also low-pressure baroreflexion. Periodical changes in blood pressure known as the so-called Traube-Hering waves, which are related to autonomous regulation and partly influenced by respiration. Relationships between respiration and changes in heart rhythm are mentioned in the study by Goldberger et al. (1984).

Respiratory frequency and respiratory volume, respectively intensity of breathing, influence changes in the actual functional activity of ANS. Changes in heart rate variability influenced by breathing during resting conditions known as the so called heart respiratory arrhythmia, thus express a relation among vagus activity, respiration and the modulation of heart rate. By observing the changes in heart rate variability during spontaneous respiration and during voluntary respiratory pattern, we can thus observe the relationship between respiration and actual changes in heart rate variability, respectively changes in the functional activity of the nervous system (Goldberger et al., 1994; Grosmann, 1992b; Katona & Jih, 1975; Malik, 1998).

Mutual relations among respiration, functional activity of the autonomous nervous system and cortical regulation of respiration are empirically used, for instance, in the Indian practise of respiratory exercises (pranajama). This part of so-called hathayoga is regarded traditionally to be the most important component of yoga exercises (Dostálek, 1996). In Western culture, respiratory gymnastics originated from a yoga-type respiration used for healing of ventilation disorders.

The influence of some yoga respiratory techniques on changes in lung ventilation was studied in the past and duly published in the papers by Frostel, Pande, and Hedenstierna (1983), Gore and Gharote (1987), and Miles (1964). Frostel, Pande, and Hedenstierna (1983) state that during rapid diaphragmatic respiration, with the so-called technique of kapalabhaty which we used as one of the yoga techniques in our research, changes in blood gas concentration do not occur. Raghujah and Telles (2003) describe the influence of supported respiration through one nostril on changes in ANS activity.

Some auto concentration techniques using the effect of respiratory techniques and their influence on changes in cerebral cortex activity were described in studies by Dostálek and Krása (1976), Fabián, Lepičovská, and Dostálek (1982), Lepičovská and Dostálek (1981), Meyer and Gotoh (1960).

The influence of respiration on blood pressure decrease was described in the works of Patel (1978). In the works of Ornish (1991) the complex effect of yoga exercise is described and the practise of breathing on positive changes in stenosal coronary vessels section

in patients with ischemic heart disorder played an important role. The use of spectral analysis of heart rate variability when assessing the effect of respiratory techniques on the functional changes in the autonomous nervous system was studied in a thesis by Ježek (2001). The influence of regulated and spontaneous respiration on actual changes in the autonomous nervous system, respectively on the frequency and amplitude modulation of the respiratory bound activity of the vagus, was studied in the works of Kolisko, Salinger et al. (1997, 2001). Additionally, Brown et al. (1993), Grosmann, Beek, and Wietjes (1990), Saul, Kaplan, and Kitney (1988) studied the relation among respiration frequency, heart rate oscillation and respectively, the R-R intervals.

Some special respiratory techniques (hyperventilation etc.) are used in some special psychotherapeutic techniques (for example holotropic respiration). In the sphere of psychotherapy the effect of regulated intensified respiration is known to induce intensified relaxation responses in the body (Baštecký, Šavlík, & Šimek, 1993; Benson & Starková, 1997; Míček, 1984).

Voluntary regulation of respiration is thus regarded by us as a fundamental factor that aims to influence, through actual autonomous regulation, the activity of its partial subsystems in sympathetic and parasympathetic aspects while systematically influencing the body's activity directed by this system. That's why, since 1995, we have been engaged in the study of the problem and the possibilities of objectifying the voluntary regulation of the actual functional condition of ANS with the method of spectral analysis of heart rate variability (Kolisko, Salinger, Opavský et al., 1997).

The Vario Cardio TF4 diagnostic system used by us for assessing R-R intervals variability enables us, together with the method of spectral analysis of heart rate variability (Yamamoto & Hughson, 1991; Havano, Sakakibara, Yamada et al., 1991; Salinger, Vychodil, Novotný et al., 1995; Salinger, Pumpla, Vychodil et al., 1999), to observe non-invasively the actual functional changes in heart rate variability that reflect actual functional changes in regulation modulated by the autonomous nervous system.

The method of spectral analysis of heart rate variability enables the observation of the relationship between selected respiratory techniques and actual functional changes in heart rate variability.

The current literature does not offer detailed studies on the relations between voluntary regulation of respiration and changes in heart rate variability, respectively frequency and amplitude modulation of the frequency spectrum characterising sympathetic and vagus activities. The problems of the relationship between respiratory frequency and changes in heart rhythm is described in the works of Brown, Beightol, Koh, and Eckberk (1993), Grossman (1992a, 1992b), Grossman, Karemaker, and Wieling (1991), Grossman and Kollai (1993). Saul et al. (1988, 1989) found a relationship between respiratory frequency and respiratory sinus arrhythmia. The occurrence of respiratory sinus arrhythmia is closely related to vagus activation. In a number of published works there is a description of a marked decrease or a complete absence of respiratory sinus arrhythmia during cholinergic blockage or after vagotomy (Cacioppo et al., 1994; Katona & Jih, 1975; Kollai & Mizsci, 1990). For this reason we suppose that regulation of respiration has an extraordinary importance during activation of the vagus component of the autonomous nervous system and enables actual regulation of the sympathetic-vagus balance (Akselrod et al., 1981, 1985).

Intentionally, apart from Šlachta, Stejskal, Elfmark et al. (2002) and Stejskal, Šlachta, Elfmark et al. (2002), we did not apply the total autonomous regulation level parameter, so-called functional age, which expresses basically the functional changes in sympathetic and parasympathetic activities depending on the vertical and horizontal body position during examination.

In our study, we opted for the sitting position with an upright trunk for assessing the influence of respiration on changes in SAHRV. This position is connected with changes of diaphragm position and enables a higher effectiveness of respiratory muscles engagement (Véle, 1997; Paleček et al., 1999). That's why it is evidently empirically applied and duly recommended for respiratory and auto concentration exercises in yoga (Dostálek, 1996).

RESEARCH AIM

To find changes in heart rate variability, respectively changes in the autonomous nervous system during different breathing techniques.

RESEARCH QUESTIONS AND HYPOTHESES

1. What is the relationship between frequency of respiration and the frequency component of ANS bound to respiration which we regard as vagus activity?

2. In what manner do the values of the observed functional parameters of the spectral analysis of heart rate variability (SAHRV) change in frequency zones of very low frequency (VLF), low frequency (LF) and high frequency (HF) during rhythmised respiratory frequency of 12 cycles/min., during spontaneous respiratory frequency, during intensified respiration (so-called full yoga breath), during alternate respiration through one nostril and during rhythmised tachypnoe (the so-called technique of kapalabhaty)?

H1 During a rhythmised respiratory frequency of 12 cycles/min. frequency stabilisation appears in all examined subjects connected with respiration frequency (respiratory bound vagus activity) in the region of 0.2 Hz. During spontaneous respiration this respiratory bound frequency will depend on individual respiratory frequency.

H2 During so-called full yoga respiration characterised by higher air volume and lower respiration frequency of less than 9 cycles/min. (interval T6), we found an increase in the total spectral power in ms^2 in comparison with spontaneous respiration.

H3 By the influence of a decrease of average respiration frequency of less than 9 cycles/min. during intensified respiration in the measured interval T6, there occurs a frequency shift of respiratory bound vagus activity from the high frequency zone HF during spontaneous respiration (interval T5) to the zone of frequency component LF during intensified respiration as compared with a spontaneous respiration frequency of more than 9 cycles/min. (interval T5).

H4 Increase in a total spectral power in ms^2 at intervals T6, T8 with intensified respiration is directly related to an increase in vagus activity.

H5 During tachypnoe in the respiratory technique of kapalabhaty (respiratory frequency approximately 120 cycles/min.) there occurs a shift of respiratory bound vagus activity above the upper frequency level of 0.4 Hz determined to be the upper frequency zone in the diagnostic system Vario pulse TF4. The dominant frequency in the zone of HF will not be bound to respiration under these conditions.

METHOD

Research method

The experiment was conducted under laboratory conditions with goal-directed manipulation of independent variables (position, respiratory pattern). All participants in the experiment were selected by draw from a group of students of Faculty of Physical Culture, Palacký University. The room temperature was 20°C; the measurements were always conducted in the morning hours. The first stage of the experiment measured the resting reactivity of heart rate variability in supine-standing-supine positions at the rhytimized breathing frequency of 12 cycles/min. and then in the supine position at spontaneous respiration frequency. The second stage measurements were monitored in subsequent intervals with the subjects in sitting position performing spontaneous respiration, respectively applying the breathing technique of spontaneous respiration.

Subjects

18 men and women; aged 20–25 years, $\bar{x}$ = 22.1 years, BMI $\bar{x}$ = 23.4 healthy individuals not on medication, non-smokers, 24 hours prior to the examination there had to be an absence of elevated physical load as well as of alcohol use.

Used instrumentation

Changes in the actual functional state of the autonomous nervous system under the influence of respiratory techniques were assessed by the method of short-term spectral analysis of heart rate variability using the telemetric system of Vario TF4. Each examined interval recorded a section of 300 beats, respectively 5 minutes of recording.

The diagnostic system of Vario TF4 allows for the thorough scanning of an EKG signal registering series of successive R-R intervals and, with the use of a software system, allows for the carrying out of the method of Fourier's fast transformation of subsequent spectral analysis in the region of 0.02–0.4 Hz which is regarded as the frequency zone corresponding to ANS activity. The result of SAHRV and respectively of monitored R-R intervals is graphic and numerical analysis at the frequency level of 0.02–0.4 Hz. In this frequency zone there are three partial frequency components analysed by the software system, which are related to the activity of partial ANS subsystems.

- *Very Low Frequency - VLF within the range of 0.02-0.05 Hz.* This frequency component is not strictly identified and is usually related to the thermoregulative sympathetic activity of vessels and also to the level of circulating katecholamins and to fluctuations in the renin-angiotensin system. Regarding the fact that there are very slow frequencies ranging from 0.6–3.0 rhythms/min., the interpretation of functional changes in this zone by means of the short-term analysis of pulse frequency variability is rather difficult.
- *Low Frequency - LF within the range of 0.05-0.150 Hz.* This frequency component is related to slow fluctuations in arterial pressure and is influenced by the baroreflective sympathetic activity of vessels (the so-called Mayer's pressure wave) with a frequency domain in this frequency range. According to Malik (1998) the frequency component LF is also influenced by parasympathetic activity.
- *High Frequency - HF within the range of 0.151-0.4 Hz.* According to Malik (1998) this component is influenced entirely by efferent vagus activity. During rhythmised respiratory frequency of 10 or more

cycles/min. it is possible within this frequency range to exactly identify the frequency bound to respiration, which we regard as parasympathetic respiratory bound activity. Depending on the frequency of respiration, frequency shifts of this component occur up to the range assessed as the frequency range of LF. Apart from parasympathetic respiratory bound activity, we found in this frequency zone other subdominant frequencies whose origin remains unclear. These subdominant frequencies in the HF zone are related probably to the modulation of vagus activity induced by signals from inner organs directed by the parasympathetic system. It is also probable that harmonic frequencies evoked by respiration frequency play an expressive role in these subdominant frequencies.

- *The respiratory bound frequency component.* Frequency domain and frequency amplitude bound to respiration, which we regard as parasympathetic respiratory bound activity, is expressively bound to rhythmisation of respiratory frequency and stability of respiratory volume. By rhythmisation or observation of respiratory frequency it is possible to identify the activity of the respiratory bound frequency component. In people with rhythmised or spontaneous bradypnoe of less than 9 cycles/min., this respiratory bound frequency is found in the zone of LF frequency. The frequency shift of this respiratory bound component is 0.0167 Hz/1 per respiratory cycle (Kolisko, Salinger, Opavský et al., 1997).

  By rhythmisation of respiratory frequency at 12 cycles/min. and rhythmisation of the length of inspiration and expiration with a ratio of 2 : 3, it is possible to stabilise respiratory bound frequency at 0.2 Hz.

  Under these conditions we may unambiguously regard the HF zone as a frequency zone of parasympathetic and dominant frequency in the LF zone as "Mayer's pressure wave" relating to baroreceptor activity.

  Under conditions of stable respiratory frequency, amplitude modulation (spectral power in ms^2), which we regard to be respiratorily bound vagus activity, is influenced by respiratory volume. Together with an increase in respiratory volume, the total spectral power of the respiratory bound frequency component also increases, while with a reduction in respiratory volume it decreases.

Measurement process

1. Observation of SAHRV changes, respectively of the actual functional condition of ANS during resting conditions with a rhythmised respiratory frequency of 12 cycles/min. depending on body position; lying – interval T1, standing – interval T2, lying after orthostasis – interval T3.
2. Observation of SAHRV changes in a lying position depending on changes in respiratory rhythm; lying with a rhythmised respiratory frequency of 12 cycles/min. – interval T3, lying during spontaneous, observed respiratory frequency – interval T4.
3. Observation of respiratory techniques' effects on changes of heart rate variability, respectively on changes of the functional condition of ANS; in an observed position – sitting. Measured intervals: T5 – sitting, spontaneous respiration, T6 – sitting, intensified spontaneous respiration (full yoga breath), T7 – sitting, spontaneous respiration, T8 – sitting, alternate respiration through the right and left nostril (anuloma – viloma), T9 – sitting, spontaneous respiration, T10 – accelerated shallow diaphragm respiration (kapalabhaty).

Methods used for evaluation and processing of data obtained

The length of one scanned interval was 300 beats. Computation of SAHRV parameters was carried out by a software programme in a standard manner according to an adjusted algorithm of CGSA (coarse-graining spectral analysis) IAW Yamamoto & Hughson (1991). The number of parameters characterising ANS activity in the particular frequency zones of VLF, LF, and HF are the results of spectral analysis.

Observed functional parameters in individual observed positions

1. Total spectral power in ms^2.
2. Spectral powers of individual frequency components VLF, LF, HF in ms^2.
3. Relative spectral powers of frequency component VLF, LF, HF in % from total spectral power.
4. Ratio of spectral powers of individual frequency zones VLF/HF, LF/HF, VLF/LF.
5. Ratio of the radical of spectral powers in the LF and HF (CCVLF, CCVHF) frequency zones as an indicator of total activity in the zone LF and HF.
6. The average value of the R-R interval length at measured intervals in ms (R-R interval).
7. Dominant frequency components of VLF, LF, HF in mHz.

Statistical method used

1. Basic descriptive statistics for data description – arithmetical mean, standard deviation.
2. Wilcoxon's non-parametric test was used for analysing the significance of changes in observed parameters depending on the applied respiratory technique among selected intervals.

Goal-directed manipulated independent variable

1. Position during experiment (standing, supine, sitting).
2. Respiratory frequency (rhythmised respiratory frequency 12 cycles/min. at intervals T2, T3, spontaneous respiratory frequency at intervals T4, T5, T7, T9).
3. Special respiratory techniques used in yoga (full yoga breath), breathing alternatively through the right and left nostrils (anuloma – viloma), rapid diaphragm respiration (kapalabhaty).
4. Age (20–25 years), health condition (healthy individuals).
5. Examination conditions (without medications, 24 hours prior to the start there was an absence of elevated physical load, the consumption of alcohol, and smoking. The examination was always carried out before noon under laboratory conditions).

Observed dependent variables – experimental effects

1. The effect of orthostasis and horizontal position with a rhythmised respiratory frequency of 12 cycles/min. on changes of observed functional parameters SAHRV.
2. The effect of rhythmised and spontaneous respiratory frequency on changes of observed functional parameters SAHRV while lying.
3. The effect of a position change from lying to sitting during spontaneous respiration on the functional changes of observed functional parameters of SAHRV.
4. The effect of the voluntary regulation of the breathing pattern while sitting at the intervals T6, T8, and T10 on changes in the observed functional parameters of SAHRV in comparison to intervals with spontaneous respiration (intervals T5, T7, T9) while sitting.

Interpretation of supposed changes of observed functional parameters

A rhythmised respiratory frequency of 12 cycles/min.

We will regard to be a demonstration of parasympathetic activity the following:

- The enhancement of the absolute and relative spectral power of frequency component HF, the simultaneous increase of the parameter CCV HF in a lying position, the extension of R-R interval length and the dominant HF frequency which is bound to respiration frequency in the following relation: Respiration frequency (min^{-1}) x 0.0167 = dominant frequency HF (mHz).

We will regard the following to be a demonstration of enhanced sympathetic activity:

- A decline in total spectral power as well as in the relative and absolute spectral power of the frequency component HF, a reduction in the parameter CCV HF, an enhancement of relative spectral power in the zones VLF and LF, the enhancement of CCV VLF and LF, and a decrease in the R-R interval length.

We will regard to be a demonstration of the enhanced functional activity of the autonomous nervous system:

- The enhancement of total spectral power in ms^2.

Respiratory bound frequency, regarded as vagus activity, will be assessed as:

- The dominant frequency respiration at a frequency of 12 cycles/min. in the HF zone in the field of 0.2 Hz.

Voluntary regulation of the respiratory pattern

We will regard to be a demonstration of enhanced vagus activity, respectively respiratory bound vagus activity:

When, while using the technique of bradypnoe, the average respiratory frequency is less than 9 cycles/min. (interval T6 – full yoga breath, interval T8 – anuloma, viloma).

- The enhancement of total spectral power; the enhancement of the relative power of the frequency component LF and the dominant frequency in the LF zone that is bound to respiration frequency; a simultaneous decrease in the absolute as well as in relative power in the zone of frequency component HF (effect of the shift of a respiratory bound frequency into the zone of the LF frequency component).

During intensified shallow diaphragm breathing (kapalabhaty technique).

- A total reduction in spectral power, a marked reduction in the absolute spectral power of the HF frequency component, and a simultaneous extension of R-R intervals.

RESULTS

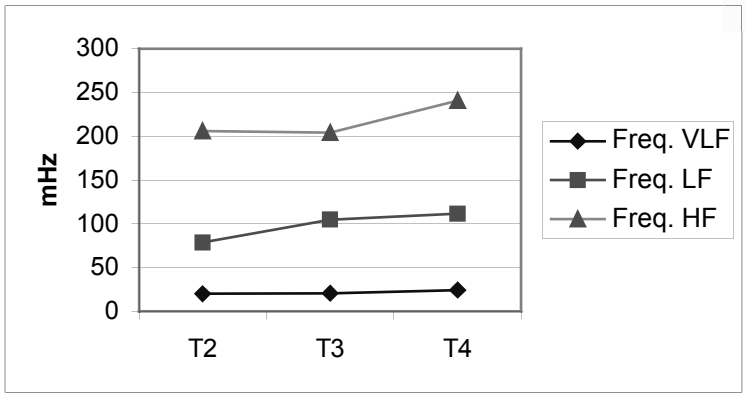
1. Frequency changes in HF and LF components in observed respiratory techniques depending on respiration frequency (TABLES 1–5; Fig. 1 and 2).

During examination of heart rate variability at a rhythmised respiratory frequency of 12 cycles/min. at interval T2 (standing) and at interval T3 (lying after orthostasis) the frequency bound to the respiratory frequency in the region of 0.2 Hz in the field of high frequency component HF with low values of standard deviation was dominant (TABLE 1, Fig. 1). This frequency range for the given condition we regard to be the frequency zone of total parasympathetic activity. At T4 (lying with spontaneous respiration) the average value of respiration in the examined individuals was 11.8 cycles/min. The standard deviation value thus shows considerable variability in the value of average respiratory frequency. Under these conditions when individual shifts of frequency bound to respiration occur, the average value of the observed respiratory frequency does not relate strictly to the average value of minute respiration calculated from the relationship between respiratory frequency

TABLE 1
Changes in selected functional parameters of SAHRV at intervals with rhythmised and spontaneous respiratory frequency

	T2 standing, rhytm. resp.		T3 lying, rhytm. resp.		T4 lying, spont. resp.		Stat. sig.
Parameter	$\bar{x}$	S	$\bar{x}$	S	$\bar{x}$	S	T3 : T4
Spect. pow. VLF	1566.6	1275.85	540.42	383.57	969.42	1101.77	
Spect. pow. LF	1116.5	758.81	740.87	698.45	1788.66	1685.13	*
Spect. pow. HF	1261.4	1017.36	5974.87	5492.28	4705.76	4976.35	
Rel. sp. pow VLF	39.54	15.74	9.26	6.46	15.11	11.27	*
Rel. sp. pow LF	29.75	11.67	11.89	9.05	24.08	19.18	*
Rel. sp. pow HF	30.71	14.58	78.84	11.37	60.81	19.57	**
Freq. VLF	20.15	5.47	20.89	3.85	24.17	8.32	
Freq. LF	78.72	15.42	104.61	29.76	111.46	28.73	
Freq. HF	206.37	7.62	204.35	12.35	241.15	73.7	
Rat. LF/HF	1.33	0.96	0.18	0.18	0.38	0.36	**
R-R interval	0.75	0.12	1.09	0.16	1.1	0.17	
CCV LF	4.29	1.47	2.27	0.83	3.42	1.81	
CCV HF	4.47	2.02	6.59	2.68	5.73	2.96	*
Total spect. pow.	3944.1	2596.02	7256.17	5886.94	7463.5	6592.97	
Resp. freq./min.	12	0.45	12	0.7	11.8	3.8	
Counted Fr. resp.	12.34	0.46	12.21	0.74	14.49	4.41	

Fig. 1
Changes in dominant frequencies at frequency component zones of VLF, LF and HF during lying with rhythmised respiratory frequency of 12 cycles/min. during standing (interval T2), during lying (interval T3), during spontaneous respiratory frequency (interval T4)

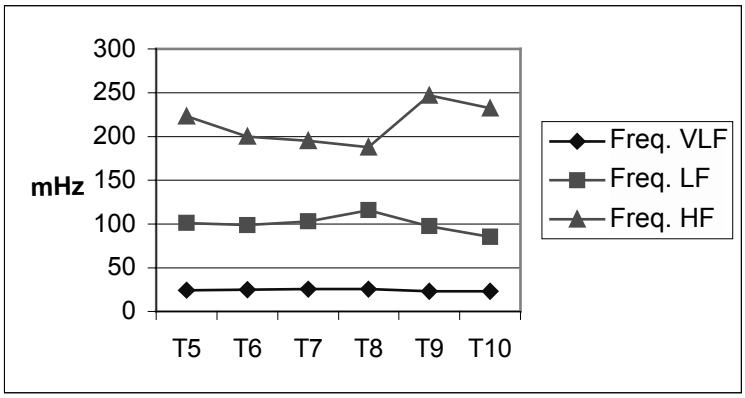


and the position of respiratory bound frequency (TABLE 1). During spontaneous respiration, the ratio between respiratory volume and respiratory frequency and the ratio between the duration of inspiration to expiration fluctuates. These individual oscillations of respiratory rhythm during the measured interval, coupled with spontaneous respiration, create frequency and amplitude modulation in the component bound to respiration regarded as vagus activity. A high variability of respiratory bound frequency values is the result of these frequency shifts during spontaneous respiratory frequency. In the graphic and numerical protocol of SAHRV results and in young healthy individuals it is possible to precisely analyse the position of this component.

TABLE 2
Changes in selected functional parameters of SAHRV at intervals with spontaneous respiratory frequency during lying (interval T4) and sitting (interval T5)

	T4 spont. resp.		T5 spont resp.		Stat. sig
Parameter	$\bar{x}$	S	$\bar{x}$	S	T4 : T5
Spect. pow. VLF	969.42	1101.77	684.65	400.04	
Spect. pow. LF	1788.6	1685.13	1717.78	1660.45	
Spect. pow. HF	4705.7	4976.35	2561.35	2212.73	*
Rel. sp. pow VLF	15.11	11.27	16.55	12.37	
Rel. sp. pow LF	24.08	19.18	34.16	25.38	
Rel. sp. pow HF	60.81	19.57	49.29	23.29	
Freq. VLF	24.17	8.32	24.29	8.17	
Freq. LF	111.46	28.73	101.37	32.86	
Freq. HF	241.15	73.7	223.07	82.85	
Rat. LF/HF	0.38	0.36	0.67	0.16	
R-R interval	1.1	0.17	0.99	0.15	**
CCV LF	3.42	1.81	3.84	2.12	
CCV HF	5.73	2.96	4.75	2.09	
Total spect. pow.	7463.5	6592.97	4963.78	3106.21	*
Resp. freq./min.	11.8	3.8	11.4	3.I	
Counted Fr. resp.	14.49	4.41	13.57	4.9	

Fig. 2
Changes in dominant frequencies at frequency component zones of VLF, LF and HF during sitting with full yoga respiration (interval T6), with alternate respiration (interval T8), during kapalabhaty (interval T10); intervals T5, T7, T9 during spontaneous respiratory frequency



In all the following positions of sitting during spontaneous respiration (positions T5, T7, T9) we found similar disproportions between the observed respiratory frequency and the respiratory frequency calculated from the relation RvFr. (mHz) = Fr. R (min^{-1}) × 0,0167 (Hz), (RvFr. – respiratory bound frequency regarded as vagus activity in the frequency zone HF or LF, Fr.R – average value of respiratory frequency) (TABLES 2–5, Fig. 2).

The position of sitting with full yoga breathing (interval T6) was characterised by a distinct slowdown of respiratory rhythm of less than 9 cycles/min. and a simultaneous enhancement of respiratory volume. Calculated respiratory frequency in these positions assumed just the relationship to dominant activity only, in the zone of frequency component LF. In the literature, the dominant frequency in this zone is related to baroreceptor activity. In our research there is just a frequency shift of frequency bound to respiration from the HF zone into the frequency zone of LF depending on the respiration frequency. The dominant frequency bound to respiration that we regard as vagus

Fig. 3
Changes in the total spectral power and partial spectral powers of frequency components VLF, LF, HF during lying with rhythmised respiratory frequency 12 cycles/min., during standing (interval T2), during lying (interval T3), during lying with spontaneous respiratory frequency (interval T4)

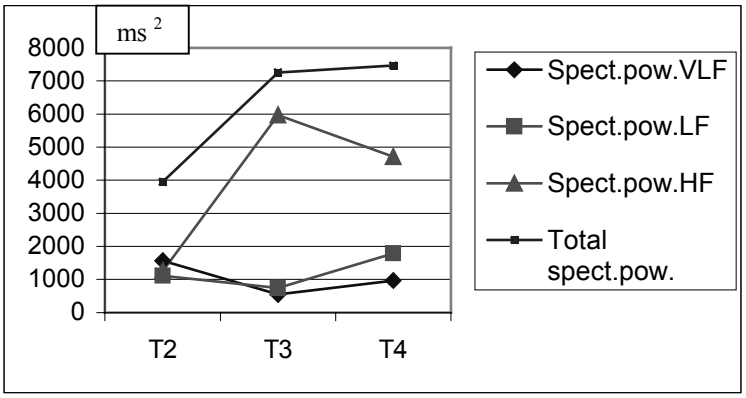
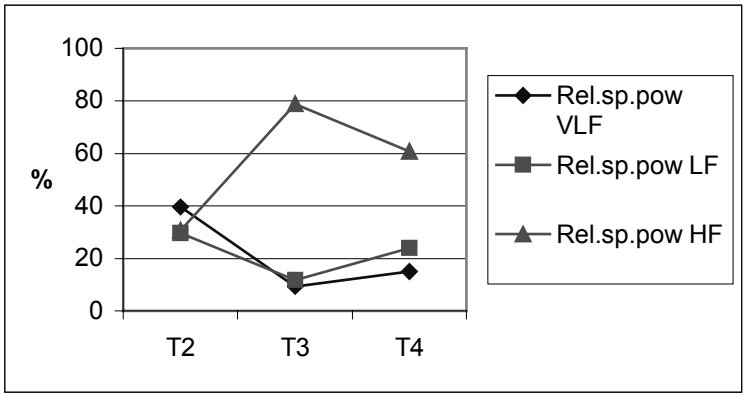


Fig. 4
Changes in the relative spectral powers of frequency components VLF, LF, HF during lying with rhythmised respiratory frequency 12 cycles/min., during standing (interval T2), during lying (interval T3), during lying with spontaneous respiratory frequency (interval T4)



activity, respectively frequency shifts, during change of respiration frequency, thus influences the actual activity and functional parameters in the zones evaluated by the software system Vario TF4, Vario Cardio and the following version as frequency components LF and HF. The border between frequency zone LF and HF is 0.15 Hz. During the respiratory frequency of 9 cycles/min we find respiratory bound vagus activity on the border of both frequency components.

At interval T10 (rapid diaphragmal respiration – so-called technique of kapalabhaty, average frequency of respiration 107 cycles/min.) the frequency component ANS bound to the respiration frequency moved above the spectral field 0.4, respectively 0.5 Hz was registered by the diagnostic system Vario TF4. During average respiration of 107 cycles/min. this frequency bound on respiration frequency probably was situated in the zone 1.79 Hz (TABLE 5). Residual dominant and other subdominant frequencies in zone HF under these conditions do not have a direct bearing on the respiratory bound vagus activity. Under the given conditions it is probably possible to regard frequency activity and its modulation in this zone as parasympathetic activity originating from sources other than vagus activity bound to respiration.

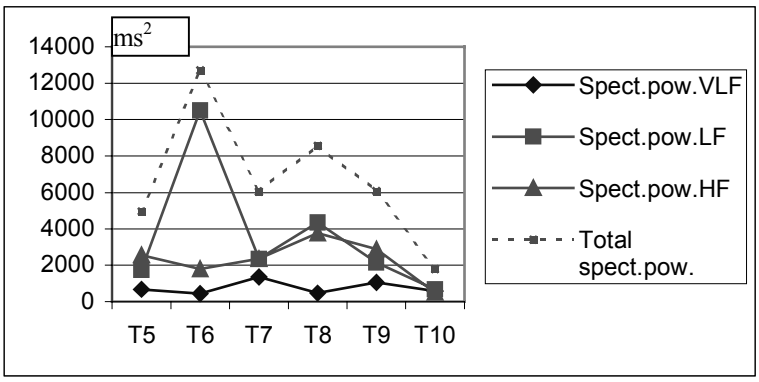
2. Changes in other observed functional SAHRV parameters depending on the respiration technique

We regard as a demonstration of the enhancement of the total functional activity of the autonomous nervous system to be, among others, the enhancement of total spectral power in ms^2 during each observed position. We compared mutually:

TABLE 3
Changes in selected functional parameters of SAHRV at intervals during sitting with spontaneous respiration (interval T5) and full yoga respiration (interval T6)

	T5 spont. resp.		T6 full yoga breathing		Stat. sig
Parameter	$\bar{x}$	S	$\bar{x}$	S	T5 : T6
Spect. pow. VLF	684.65	400.04	426.93	267.33	*
Spect. pow. LF	1717.7	1660.45	10494.2	7862.34	**
Spect. pow. HF	2561.3	2212.73	1794.68	1822.89	
Rel. sp. pow VLF	16.55	12.37	5.84	6.63	**
Rel. sp. pow LF	34.16	25.38	76.03	22.28	**
Rel. sp. pow HF	49.29	23.29	18.13	20.48	**
Freq. VLF	24.29	8.17	25.2	9.27	
Freq. LF	101.37	32.86	98.57	26.95	
Freq. HF	223.07	82.85	199.73	60.51	
Rat. LF/HF	0.67	0.16	5.84	4.21	**
R-R interval	0.99	0.15	0.94	0.14	**
CCV LF	3.84	2.12	9.93	4.22	
CCV HF	4.75	2.09	4.08	1.1	
Total spect. pow.	4963.7	3106.21	12715.8	8288.26	**
Resp. freq./min.	11.4	3.1	6.4	1.8	
Counted Fr. resp.	13.57	4.9	11.98	3.64	

Fig. 5
Changes in the total spectral power and partial spectral powers of frequency components VLF, LF, HF during sitting with full yoga respiration (interval T6), during alternate respiration (interval T8), during kapalabhaty (interval T10); intervals T5, T7, T9 with spontaneous respiratory frequency (ms^2)



2.1 Rhythmised and spontaneous respiration (TABLE 1, Fig. 3, and 4)

During comparison of intervals while lying (T3 rhythmised respiration 12 cycles/min., T4 spontaneous respiration) we did not find any significant changes in the total spectral power. Concurrently, there occurred an enhancement of spectral power in the frequency components VLF and LF, and a reduction in the spectral power of the HF component. Similar changes were observed in the case of relative spectral powers. There an enhancement in LF/HF ratio and decrease of CCVHF parameter occurred. The mentioned changes are related to a higher variability of individual respiratory frequency in the examined sample during spontaneous respiration (TABLE 1).

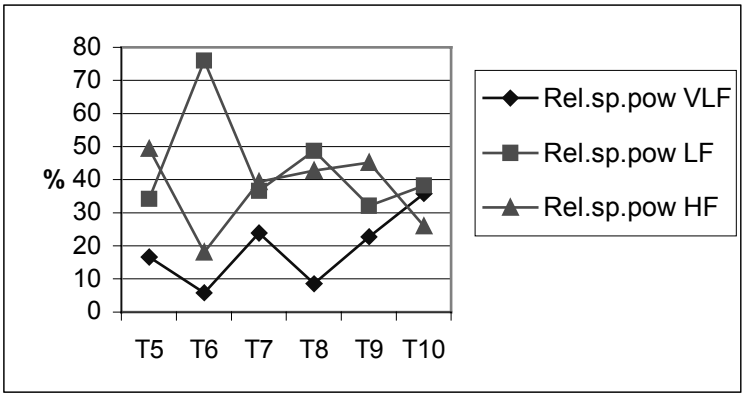
2.2 Position change from lying to sitting during spontaneous respiration (TABLE 2)

During a position change from lying (interval T4) to sitting (interval T5), we found a significant reduction in total spectral power (sitting as a demonstration of partial orthostasis). Concurrently, a significant reduction in the spectral power of the frequency component HF, a reduction in the relative spectral power HF,

TABLE 4
Changes in selected functional parameters of SAHRV at intervals during sitting with spontaneous respiration (interval T7) and alternate respiration (interval T8)

	T7 spont. resp.		T8 anuloma-viloma breathing		Stat.sign
Parameter	$\bar{x}$	S	$\bar{x}$	S	T7 : T8
Spect. pow. VLF	1352.3	1236.36	477.28	253.19	**
Spect. pow. LF	2340.7	2356.73	4333.62	4995.73	**
Spect. pow. HF	2343.4	2164.54	3769.78	4106.91	
Rel. sp. pow VLF	23.95	14.63	8.53	7.01	**
Rel. sp. pow LF	36.63	24.21	48.75	27.83	**
Rel. sp. pow HF	39.42	21.99	42.72	28.95	**
Freq. VLF	25.84	8.63	25.51	8.99	
Freq. LF	102.99	27.07	115.59	26.35	
Freq. HF	195.12	37.83	188.01	32.07	
Rat. LF/HF	2.92	5.41	1.15	0.89	
R-R interval	0.97	0.15	0.98	0.15	
CCV LF	4.61	2.43	6.02	3.42	
CCV HF	4.62	2.28	5.64	3.22	
Total spect. pow.	6036.1	3352.88	8580.68	5892.08	
Resp. freq./min.	10.74	2.91	7.62	1.74	
Counted Fr. resp.	11.75	2.23	11.26	1.92	

Fig. 6
Changes in the relative spectral powers of frequency components VLF, LF, HF



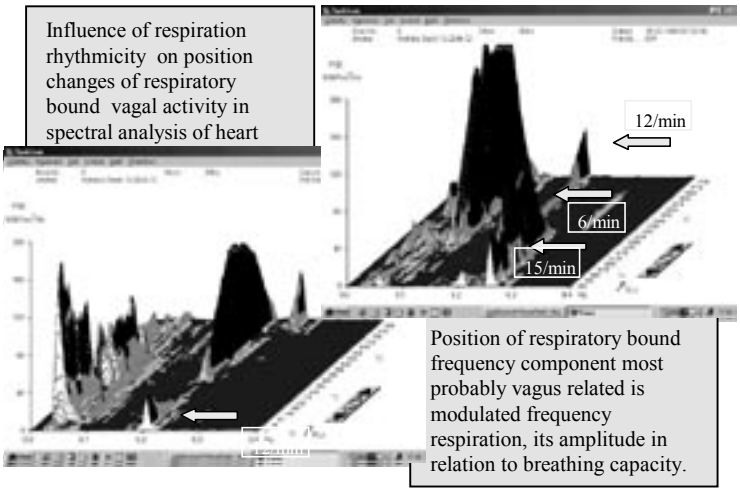
an enhancement of the ratio in the spectral powers LF/HF, a reduction in the CCVHF parameter, and a shortening of the R-R interval, occurred. The mentioned changes characterise a sitting when compared to a lying position as a position with a partial orthostatic load under the influence of the activity of the trunk postural muscles.

2.3 Full yoga breathing and spontaneous respiration during sitting (TABLE 3, Fig. 5, 6)
During full yoga breathing (interval T6) a significant enhancement in the total spectral power, compared with spontaneous respiratory frequency, occurred, which is very probably related to the intensity of the respiratory volume. In the following positions during spontaneous respiration, the total spectral power again significantly declined. A frequency shift of respiratory bound vagus activity from the HF zone into the LF zone happens as a result of a decrease in respiratory frequency ($\bar{x}$ = 6.4) and simultaneously the spectral power of this frequency component increases influenced by the enhancement of respiratory volume. A frequency shift of respiratory bound vagus activity owing to a change in respiratory frequency has a linear character; changes in ampli-

TABLE 5
Changes in selected functional parameters of SAHRV at intervals during sitting with spontaneous respiration (interval T9) and fast rhythmised respiration – kapalabhaty (interval T10)

	T9 spont.resp.		T10 kapalabhaty		Stat.sig
Parameter	$\bar{x}$	S	$\bar{x}$	S	T9 : T10
Spect. pow. VLF	1067.09	709.89	598.09	404.19	
Spect. pow. LF	2145.9	2249.28	681.63	501.49	**
Spect. pow. HF	2866.9	2228.97	513.33	472.82	**
Rel. sp. pow VLF	22.73	17.53	35.81	15.11	*
Rel. sp. pow LF	32.05	20.56	38.25	12.35	
Rel. sp. pow HF	45.22	23.38	25.93	12.16	**
Freq. VLF	23.09	7.58	23	7.21	
Freq. LF	97.8	31.44	85.38	18.91	
Freq. HF	246.7	89.97	232.16	114.22	
Rat. LF/HF	0.75	0.52	1.33	0.96	
R-R interval	0.98	0.14	0.89	0.17	**
CCV LF	4.18	2.03	2.94	1.38	
CCV HF	5.02	2.37	2.43	1.34	**
Total spect. pow.	6078.7	3568.39	1793.06	1139.74	**
Resp. freq./min.	11.8	3.2	107.4	14.4	
Counted Fr. resp.	14.77	5.37	13.9	6.84	

Fig. 7
Frequency and amplitude changes in respiratory bound vagus activity in frequency zone HF during respiration frequency of 12 cycles/min., 15 cycles/min., 12 cycles/min. and in frequency zone LF during respiration 6 cycles/min.



tude of this frequency, modulated by respiratory volume, exhibit exponential character.

2.4 Alternating breathing through right and left nostrils and spontaneous respiration (TABLE 4, Fig. 5, 6)
During alternating respiration through the right and left nostrils (interval T8) the enhancement of total spectral power happened compared with previous positions with spontaneous respiration (interval T7), and the resulting changes were not significant. In the following position T9 during spontaneous respiration, a reduction in the total spectral power at the starting level T7 occurred. During this technique of respiration, a significant reduction in the spectral power of frequency component VLF, in enhancement of activity

in the LF zone and non-significant enhancement in the HF zone, occurred. A similar reaction can be found in relative spectral powers. Similar trends can also be found in CCVLF and CCVHF parameters. Interpretation of frequency and amplitude changes during the use of this respiratory technique is unclear. Enhancement of activity in the dominant frequency in the LF zone is partially influenced by variation in individual respiratory frequency values. It is not clear why simultaneous enhancement of activity in the HF zone happens. The question raised here is whether partial enhancement of respiratory resistance in upper airways during blockage of one nostril does not have any relation to increased vagus activity.

2.5 Rapid rhythmic diaphragm breathing (kapalabhaty) and spontaneous respiration (TABLE 5, Fig. 5, 6)
At interval T10 as compared to the T9 interval, there was a distinct reduction of total spectral power and a simultaneous decline of spectral power in all partial frequency components. These changes of spectral powers create a functional picture of a stress situation. During use of this technique of respiration shift of frequency bound on respiration frequency happened in the sphere of frequency that is above the frequency field of 0.4 Hz, which is the upper frequency zone registered by the diagnostic system Vario TF4 and other variants of the device. Respiratory bound vagus activity is thus out of the frequency zone of the HF frequency component. In the zone of this HF frequency component (0.2–0.4 Hz) we find a dominant frequency that is not bound to respiratory frequency and its source is unclear. If we regard the HF zone as total parasympathetic activity, then it is possible to consider these frequencies in the HF zone as a source of parasympathetic activity originating in the inner organs innervated by the nervus vagus.

DISCUSSION

The relationship between rhythmised respiratory frequency and spontaneous respiratory frequency while lying, and observed SAHRV changes

It is essential to regard respiratory pattern as a fundamental factor in modulating the actual functional activity of the autonomous nervous system. Rhytmisation of respiratory frequency stabilises the position of respiratory bound frequency regarded to be a basic functional component linked to parasympathetic activity. We found the relationship of respiratory frequency to respiratory bound frequency as determined by the numeric relation RvFr (mHz) = 0.0167 (Hz) × Rf/min. described in the works of Kolisko, Salinger, Opavský et al. (1997) in the sample of examined people during the use of a standardly rhythmised respiratory frequency of 12 cycles/min. while standing and also in the lying position. Also, Brown et al. (1993) arrived at similar results on the relationship between respiratory frequency and R-R interval fluctuation.

Under these conditions we can unambiguously assess the activity in the HF zone in the output listing of SAHRV as total parasympathetic activity. If we regard respiratory frequency in harmony with Paleček et al. (1999), and Ganong (1999) as an ergonomically optimal functional coalition of respiratory frequency, respiratory volume and muscle tone of the inspiratory and expiratory muscles, we did not find during rhythmised respiratory frequency any significant decrease in total spectral power that would signal rhythmised respiratory frequency to be perceived by the body reflectively as a specific kind of load.

At intervals with spontaneous respiration, a considerable variability of individual respiratory frequency occurred within the observed sample. It is very probable that the changes in spectral powers and in the relative spectral powers of LF and HF frequency components during spontaneous respiration, when compared to rhythmised respiratory frequency are modulated by the influence of value variability in individual respiratory frequency during measured intervals.

The relationship between the change from the lying to the sitting position during the use of spontaneous respiratory frequency and the observed SAHRV changes

The change from a lying to a sitting position during spontaneous respiration is perceived reflexively in the body as a specific type of postural load when reduction of total spectral power and a significant reduction of activity in the zone of the HF frequency component occur in comparison to the lying position. Since sitting is understoood by us to be partial orthostasis, changes in ANS reactivity are not so typical compared to standing and lying positions. The sitting position is, however, functionally suitable for more effective engagement of respiratory muscles during inspiration and the facilitation of a respiratory pattern with prevailing diaphragm respiration. Apparently for this reason, the oriental techniques of respiratory exercises recommend sitting with crossed legs or sitting on one's heels as basic positions during autoregulative exercises emphasising an upright trunk position.

The relationship among spontaneous respiration frequency, selected respiration techniques and observed SAHRV parameters

Intensified respiration with continual engagement of inspiration and expiration muscles (the so-called technique of full yoga respiration) is characterised by intensification of respiration volume, a decrease in

respiration frequency and a higher level of inspiration and expiration muscle activation. Decrease of respiratory frequency led to a shift of frequency component bound to respiration that we regard as vagus activity in the spectral field in the sphere of LF frequency component. According to Paleček et al. (1999), intensifying respiratory volume influences pressure proportion in the lungs and reflectively stimulates total vagus activity. When compared to spontaneous respiration, we found significant enhancement of total spectral power, that we regard as the demonstration of total activity of the autonomous nervous system. Respiratory bound vagus activity moved during bradypnoe into the sphere of the LF frequency component, mainly participating in the enhancement of total spectral power. Respiratory bound vagus activity, respectively frequency and amplitude changes are influenced by the relationship between respiratory frequency and volume. Their dominant frequency in the zone of the HF frequency component was not bound in this case to respiration and its source is still unclear. The influence of the activity of other inner organs, parasympathetically directed, comes under consideration. There is also the probability that the dominant frequency in the HF zone is a harmonic frequency influenced by a frequency shift of the dominant frequency bound to respiration.

Respiring alternatively through the right and left nostrils (the technique of anuloma viloma) was linked with a decrease in respiratory frequency, enhancement of respiratory volume and partial enhancement of upper airways resistance when compared to spontaneous respiration. According to empirical experience, this respiratory technique is regarded as a so-called harmonised respiration technique, leading to a subjective feeling of mental calming when applied. This technique presented itself within the results of the spectral analysis of heart rate variability as a non-significant enhancement of total spectral power, a decrease in spectral power in the zone of the VLF frequency component and, at the same time, an enhancement of spectral power in the sphere of LF and HF frequency components. The spectral power of the LF frequency component was very probably modulated by a shift of respiratory bound parasympathetic activity during the slowing of respiratory frequency to less than 9 cycles/min. from the HF zone during spontaneous respiration into the LF zone during application of this technique. Compared to spontaneous respiration it is possible to understand this technique specifically as relaxation and as a regenerative technique that increases the share of parasympathetic activity in the total ANS activity.

The kapalabhaty technique consists of shallow rapid diaphragm breathing with a frequency of about 120 cycles/min. During this respiratory technique we observed a significant reduction in the total spectral power and a concurrent reduction in the spectral powers in all three partial spectral components. Respiratory bound vagus activity shifted during the use of this technique above the upper frequency zone of 0.4, respectively 0.5, Hz and its frequency, we suppose, regarding the average respiration frequency of 107.4 cycles/min. in the proximity of 1.79 Hz. The picture of SAHRV changes during this technique is a reflection of a specific stress situation characterised by a higher share of sympathetic activity regulating cardiac activity. The origin of lurking frequency activity in the zone of HF frequency component that is not bound to respiration is still unclear. The origin of these frequencies in the HF zone we probably see as activity that is modulated by signals from other inner organs innervated by the vagus nerve.

CONCLUSIONS

- Respiratory pattern is a fundamental factor that objectively influences the actual functional activity of the autonomous nervous system and increases the extent of vagus activity in its total activity.
- Respiration frequency actually influences the position of respiratory bound frequency that we regard as vagus activity. The position of respiratory bound vagus activity can be expressed by the numeric relation **RvFr** (mHz) **= 0.0167 × Rf/min.** during examination by SAHRV method. (Question no. 1, confirmation of hypothesis no. 1.)
- Rhythmisation of respiration, respectively stability of respiratory frequency and stability of respiratory volume, stabilises the frequency and amplitude of respiratory bound vagus activity.
- During bradypnoe with a respiratory frequency of less than 9 cycles/min., a shift of respiratory bound activity happens, from the HF frequency component into the zone of the LF frequency component. Respiratory bound vagus activity, under these conditions, becomes the dominant frequency in the zone of the LF component. (Confirmation of hypothesis no. 3.)
- An increase in respiratory volume during the use of the bradypnoe technique of full yoga breath increases significantly the amplitude modulation (spectral power in ms^2) of respiratory bound vagus activity. Enhancement of ANS activity with a higher dominance of parasympathetic activity is the effect of this type of respiration. (Confirmation of hypotheses no. 2, 4.)
- The so-called technique of kapalabhaty (tachypnoe) can be regarded as a specific type of physical load that decreases markedly the variability of R-R intervals.
- Frequency activity in the zone of the HF frequency component during use of the kapalabhaty technique when the frequency shift of respiratory bound vagus

activity out of the registered frequency spectrum is regarded as activity in the HF zone that is not bound to respiration as an activity originating probably from parasympathetically directed signals from inner organs. (Confirmation of hypothesis no. 5.)

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VYUŽITÍ METODY SPEKTRÁLNÍ ANALÝZY VARIABILITY SRDEČNÍ FREKVENCE PŘI HODNOCENÍ EFEKTU VYBRANÝCH DECHOVÝCH TECHNIK NA AKTUÁLNÍ FUNKČNÍ ZMĚNY AUTONOMNÍHO NERVOVÉHO SYSTÉMU

(Souhrn anglického textu)

Dýchání je jeden ze základních faktorů, které ovlivňují aktuální funkční stav autonomního nervového systému. V naší výzkumné studii jsme se pokusili objasnit s využitím diagnostického systému Varia Cardio TF4 a metody spektrální analýzy variability srdeční frekvence vliv volní regulace dechového vzoru na aktuální funkční změny variability R-R intervalů, které úzce souvisí s vlivem regulace n. vagus na změny variability R-R intervalů. Sledovali jsme tak vliv vybraných jógových technik dýchání na frekvenční a amplitudové změny ve sledovaném frekvenčním spektru 0,02–0,4 Hz, které souvisí s aktivitou autonomního nervového systému. Jednu z frekvenčních komponent v tomto pásmu tvoří respiračně vázaná aktivita vagu. Tato frekvence a její amplituda se výrazně stabilizuje při rytmizaci dechové frekvence. U dechových technik s prohloubeným dýcháním dochází k výraznému zvýšení celkového spektrálního výkonu, na kterém se podílí především frekvenční komponenta, kterou považujeme za respiračně vázanou aktivitu vagu. Amplituda této frekvence je modulována dechovým objemem a aktivitou inspiračních svalů, její frekvence se v závislosti na rytmicitě dýchání mění o 0,0167 Hz/1 dechový cyklus. Během rytmizované dechové frekvence 12 cyklů/min. a poměru rychlosti inspiria k expiriu 2 : 3 nacházíme tuto frekvenční komponentu stabilizovanou v pásmu 0,2 Hz.

Klíčová slova: variabilita srdeční frekvence, autonomní nervový systém, regulované/spontánní dýchání.

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THE AGILITY TEST IN FUNCTIONAL DIAGNOSTICS OF ATHLETES

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The paper deals with the agility test as a diagnostic method for the assessment of the multi choice reaction time of the lower limbs. A group of 236 athletes (mean age 21.5 ± 2.9 years, height 178.1 ± 8.1 cm, and weight 72.2 ± 9.4 kg) performed an agility test. They had to touch with either the left or right lower extremity one of the four pads located in four corners inside of a 80 cm square. Pads had to be touched in accordance with the location of a stimulus generated in one of the corners of the screen. The computer based system FiTRO Agility Check was used to generate the stimuli and measure corresponding reaction times. The results showed better agility of lower limbs in adults than in children. Cross sectional tests revealed that competitors in table tennis, fencing, karate, ice hockey, soccer, basketball, volleyball, and aikido performed significantly better than physical education students, judokas and wrestlers. In a group of eight 15-yr old female volleyball players, a repeated test after 6 weeks of training aimed at reaction and speed abilities showed a significantly shorter reaction time as compared to general training. A one-year training period in volleyball led to a significant improvement of the agility skills of athletes related to their actual ranking. The results obtained indicate that the agility test allows talent identification, differentiation of athletes with different performance levels in agility skills as well as changes of these abilities during short and long term training periods.

Keywords: Agility test, multi choice reaction time, sport motor testing, talent identification, training.

INTRODUCTION

Multi choice reaction time and movement velocity are the most principal capabilities to be measured in many sports, such as tennis, fencing, karate, ice hockey, soccer, basketball, volleyball, aikido, etc. For their assessment a computer based portable device was developed in a laboratory of the Institute of Sport Sciences by Hamar et al. (1997). The main task of subjects is to touch the contact switch pad in one of four directions according to the position of the stimulus on the screen (Fig. 1a and 1b). As a result the reaction time in each direction is displayed (TABLE 1). Its advantage is that it provides laboratory accuracy in field-testing, which is necessary, especially these days, when many of the tests are done out in the playing field or gym.

Therefore, the aim of the study was to present results and experiences with the agility test in the functional diagnosis of athletes.

MATERIAL AND METHODS

Altogether 236 subjects (mean age 21.5 ± 2.9 years, height 178.1 ± 8.1 cm, and weight 72.2 ± 9.4 kg) performed an agility test. They had to touch, as fast as possible, with either left or right lower extremity, one of the four pads located in four corners inside of an 80 cm square. Pads had to be touched in accordance with the location of a stimulus in one of the corners of the screen. The computer based system FiTRO Agility Check was used to generate the stimuli and measure the reaction times (Hamar & Zemková, 1998).

In the previous study the reliability of the test procedure was verified and the protocol standardized by the examination of 196 persons. Analysis of the repeated measures showed a measurement error of 7.1%, which is in the range comparable to common motor tests (Hamar & Zemková, 1998). The mean of the best 8 reaction times to each direction proved to be the most reliable parameter of the test consisting of 3 sets of 60 stimuli (15 in each direction) with a random generation of their localization (Zemková & Hamar, 1998).

RESULTS AND DISCUSSION

The results showed various possibilities of application of the agility test in sport motor testing of athletes:

Differentiation of groups of athletes with different demands on the agility of the lower extremities

Cross sectional tests revealed (Zemková & Hamar, 1999) that table tennis players (326.1 ± 16.0 ms), fenc-

Fig. 1a and 1b
FiTRO Agility check for the assessment of multi choice reaction time of the lower extremities

ing performers (336.6 ± 17.4 ms), karate performers (339.4 ± 33.4 ms), ice hockey players (352.1 ± 28.9 ms), soccer players (364.0 ±33.8 ms), basketball players (369.3 ± 26.3 ms), volleyball players (370.6 ± 32.1 ms), and aikido performers (389.1 ± 38.4 ms) achieved a significantly shorter reaction time in the agility test than physical education students (398.8 ± 40.9 ms), judo performers (400.3 ± 27.7 ms), and wrestlers (497.6 ± 20.9 ms) (Fig. 2). These results indicate that the test allows for differentiation of athletes with different performance levels in agility skills.

Talent identification

Reaction and speed influence performance in many sports. However, these abilities considerably depend on genetic dispositions and may be improved only by about 15 to 25%. Therefore, information about the values of reaction time in children of different ages is in sport practice useful for talent identification. On the other hand, it has to be pointed out that the accuracy of measurements of sensomotor parameters is influenced by many factors including motivation, incentive, attentiveness, etc., which are difficult to control in younger subjects. Therefore, one has to be careful using these values for selection of young sports talent.

Such a cross-sectional study showed (Zemková & Hamar, 2001) that reaction time in the agility test was 815.7 ± 100.9 ms for 7 and 8 year old children, 649.6 ± 95.2 ms for 9 and 10 year olds, 604.9 ± 97.7 ms for 11 and 12 year olds, 467.5 ± 77.6 ms for 13 and 14 year olds, 453.3 ± 38.6 ms for 14 and 15 year old youth, and 398.8 ± 40.9 ms for adults age from 20 to 26 years old (Fig. 3). This finding is in agreement with the reports of several authors (e.g. Thomas et al., 1981) who found that reaction time linearly decreased with increased age up to early maturity.

TABLE 1
An example of the results of the agility test

Name: P. K.		Date: 5. 5. 1998		Time: 16:21:34	
Test Setup: trial 1		Yellow Circle on Black Background			
Comment: hockey					
MOVEMENT DIRECTION	N (#)	BEST (ms)	WORST (ms)	AVERAGE (ms)	SD (ms)
rear left	15	299	2092	661.4	582.3
rear right	15	271	2017	561.1	433.4
front left	15	309	1220	448.4	220.6
front right	15	256	1340	522.3	345.2
TOTAL	60	256	2092	548.3	423.8

Fig. 2
The results of the agility test in various sports (n = 193)

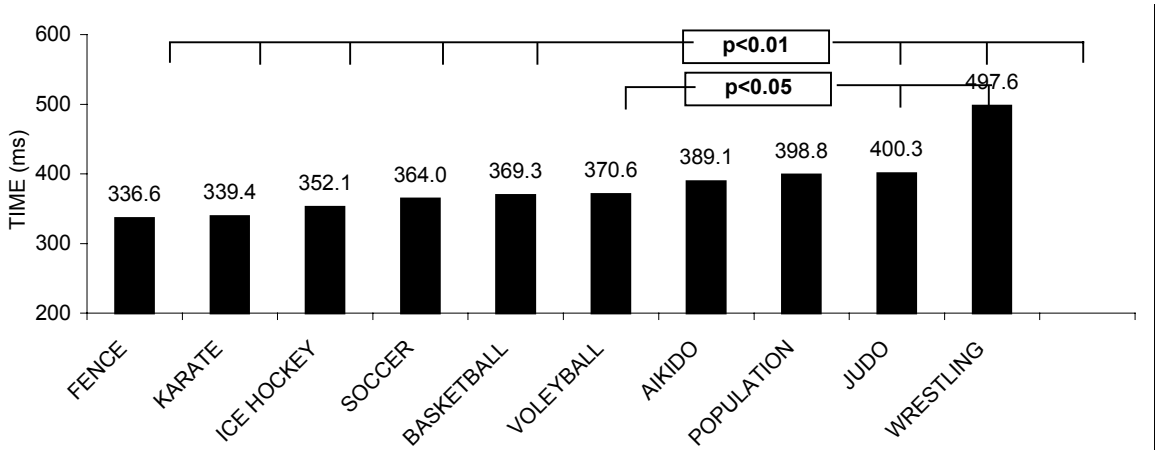
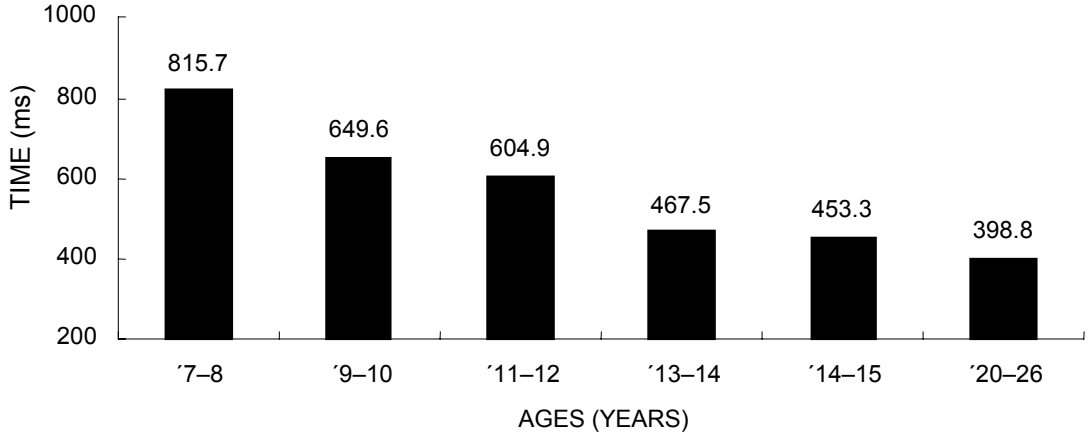


Fig. 3
The results of the agility test in subjects of various ages (n = 120)



Assessment of the effect of specific short and long term training focused on the improvement of agility skills

In a group of 15 year old female volleyball players, a test repeated after a 6 weeks period of general training, not especially aimed at reaction and speed abilities, did not show significant changes from 373.2 ± 46.8 ms to 393.7 ± 45.5 ms (Fig. 4), however, significant ($p < 0.05$) improvement occurred after a period of training focused on the improvement of the agility of the lower extremities from 395.0 ± 43.5 to 329.7 ± 53.0 ms (Fig. 5) (Luknárová & Zemková, 1997; Zemková et al., 1998).

During one year of training in the junior volleyball national team, it has been found (Luknárová et al., 1998) that parameters of agility were related to their actual ranking. At the beginning, the reaction time in the agility test was 370.6 ± 42.1 ms. Similarly, its value after summer general training was 365.8 ± 60.0 ms. However, after specific training focused on the improvement of agility skills the reaction time was significantly ($p < 0.01$) better 303.0 ± 50.2 ms than before. At the end of the competition period, its value slightly increased to 331.8 ± 38.5 ms. To sum up, after one year of training, a significant ($p < 0.05$) improvement of reaction time from 370.6 ± 42.1 ms to 331.8 ± 38.5 ms (Fig. 6) was observed.

Other applications of the agility test

The multi choice reaction times of the lower limbs when fatigued after different forms of loading may be compared. In one of our studies (Zemková et al., 1998) the effect of fatigue due to exercise bouts of different intensity on multi choice reaction abilities of the lower

Fig. 4 and 5
The results of the agility test after six weeks of general training and training focused on the improvement of the agility of the lower extremities (n = 8)

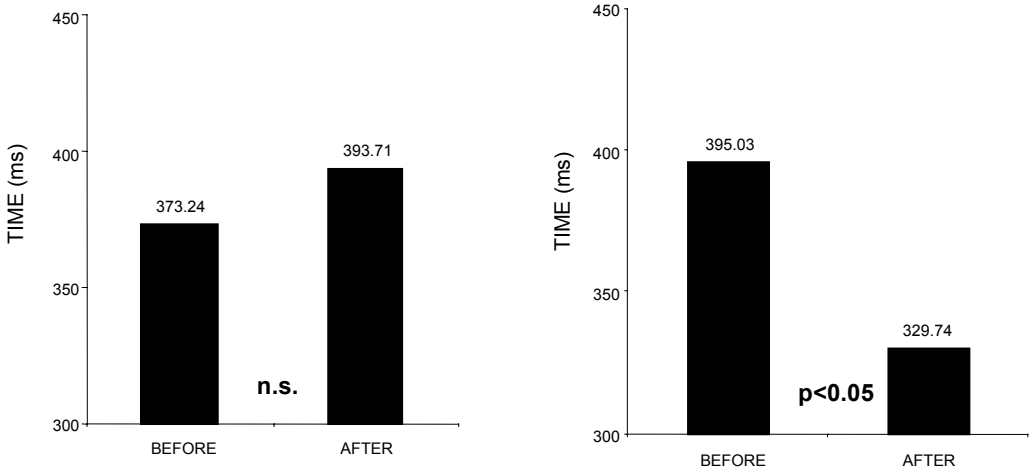


Fig. 6
The results of the agility test during a one year training period in the junior volleyball national team (n = 14)

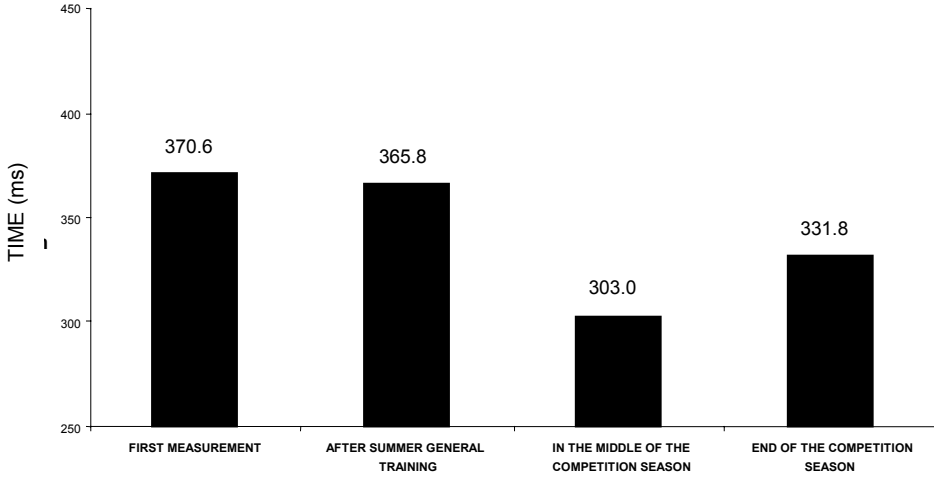
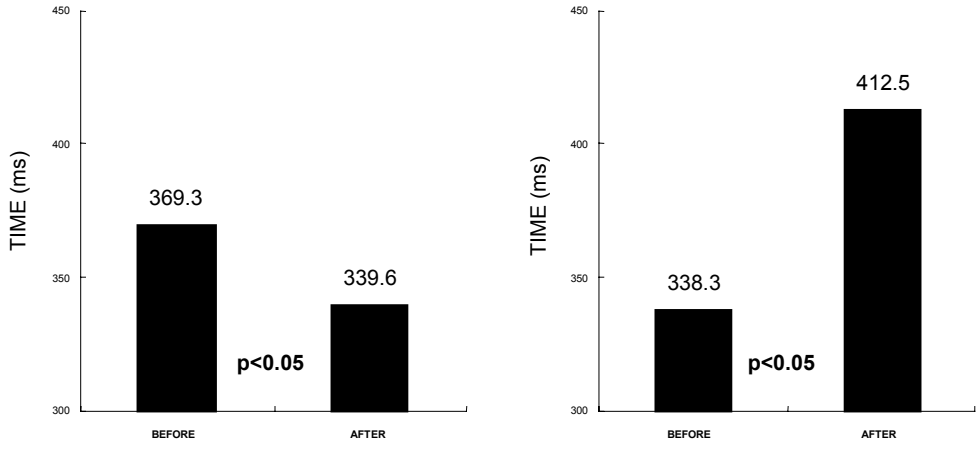


Fig. 7 and 8
The results of the agility test after exercise bouts of different intensity (n = 16)



limbs was evaluated. After exercise of moderate intensity there was a significant improvement ($p < 0.05$) of mean response time from 369.3 ± 38.6 ms to 339.6 ± 24.3 ms (Fig. 7). On the other hand, after exercise above the anaerobic threshold, there was a significant increase ($p < 0.05$) from 338.3 ± 43.9 ms to 412.5 ± 47.0 ms (Fig. 8) indicating that multiple reaction time of the lower limbs depends on the type of fatigue.

Such a phenomenon was observed in several studies. McMorris & Keen (1994) have demonstrated that simple reaction time after maximally fatiguing exercise was significantly slower than after moderate exercise. Similarly, during exercise with increasing intensity up to exhaustion it was found that the multiple reaction time decreased until the intensity exceeded the lactate threshold by approximately 25%, and then rapidly increased (Chmura et al., 1994). However, it has been reported that young athletes are able to maintain for a relatively long time, or even increase, their psychomotor performance during exercise not only below but also above the lactate threshold (Chmura et al., 1998). For such a positive effect of exercise on cognitive functioning an enhanced activation is very probably responsible (Hogervorst et al., 1996) and both the peripheral component (muscle contraction) and central nervous system integrity, primarily reflect cognitive processing speed (Birren et al., 1980).

Aside from diagnostics, the test may be applied for the purpose of the development of agility skills in various sports. Subjects may react from a position in the middle of the square of four pads or from the location of the last stimuli. In addition, the device offers a variety of test settings, i.e. time generation (constant or random), number, form, and color of the stimulus, and color of the background.

The test setting can be adjusted in accordance with a sport specific task, i.e. either four or two pads for karate (Zemková & Hamar, 1998) and fencing performers or tennis players (Psalman, 2002) in accordance with their movements on the field. In addition, a longer distance between mats (5 m) for basketball, hockey, soccer or volleyball players (Zemková et al., 2003) may be used to test multi choice reaction times in the lower extremities as well as sprint performance (Fig. 1b). For these sports such a modified version of the test is considered to be a more specific and hence more suitable alternative for the assessment of agility abilities.

CONCLUSION

It may be concluded that by means of the contact mats used, the multi choice reaction times and movement speed in a variety of agility skills may be evaluated. The test allows talent identification, differentiation of groups of athletes with different demands on agility of lower extremities, assessment of the effect of specific training focused at the improvement of these abilities as well as development of agility skills in various sports (tennis, fencing, karate, ice hockey, soccer, basketball, volleyball, aikido, etc.).

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TEST AGILITY VE FUNKČNÍ DIAGNOSTICE SPORTOVCŮ

(Souhrn anglického textu)

Na základě dosavadních zkušeností je možné test agility považovat za vhodný způsob posuzování disjunkčních reakčně-rychostních schopností a proto cílem práce bylo poukázat na některé z možností jeho využití v praxi. Celkem bylo vyšetřeno 236 sportovců (stolní tenisté, šermíři, karatisté, hokejisté, fotbalisté, basketbalisté, volejbalisté, aikidisté, judisté, zápasníci a studenti FTVŠ) průměrného věku 21,5 ± 2,9 roku, výšky 178,1 ± 8,1 cm a hmotnosti 72,2 ± 9,4 kg. Úlohou testovaných jedinců bylo reagovat na vizuální podnět na monitoru počítače a podle jeho lokalizace vykonat pohybovou odpověď příslušným směrem. Při generování podnětů a měření času reakcí bylo použito zařízení FiTRO Agility check. Výsledky poukázaly na kratší reakční čas u dospělých než u dětí. Průřezové vyšetření ukázalo, že stolní tenisté, šermíři, karatisté, hokejisté, fotbalisté, basketbalisté, volejbalisté a aikidisté dosáhli významně lepšího výsledku než studenti, judisté a zápasníci. Opakované vyšetření u volejbalistek neukázalo významné změny po 6týdenním všeobecně zaměřeném mezocyklu, k významnému zlepšení došlo až po tréninku zaměřeném speciálně na rozvoj rychlosti pohybových reakcí dolních končetin. Výsledky ukazují, že test agility kromě zaznamenávání rozdílů mezi jedinci rozdílného věku a výkonosti, umožňuje i poskytování užitečných informací o změnách těchto schopností v různém období sportovní přípravy, čímž pomáhá objektivizovat efekt tréninku speciálně zaměřeného na jejich rozvoj. Podle předběžných sledování je vhodné využívat test zejména ve sportovních hrách, úpolových sportech a ve sportech s krátkodobým výkonem, kde je důležitá rychlost pohybových reakcí a také jako součást komplexního posuzování úrovně tělesné zdatnosti u běžné populace. Navíc je možné zařízení využívat i v samotném tréninkovém procesu na rozvoj disjunkčních reakčně-rychlostních schopností.

Klíčová slova: diagnostika, disjunkční reakčně-rychlostní schopnosti, test agility, sportovní příprava, výběr talentů.

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MOTOR SKILLS IN MENTALLY RETARDED CHILDREN

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Submitted in December, 2003

The definition of aptitude takes into account functional effectiveness, as well as the quality and speed of reactions observed in an individual. Personal aptitude comprises certain abilities that are in part genetically formulated. The scope and level of these abilities vary for different individuals. Global abilities are vital for one's survival and development, whereas particular abilities are crucial for defining one's individuality, both physical and psychological. The research whose results are described in this work emphasized motor skills of mentally retarded children. The examinations were conducted among 49 children aged 10–19 attending the Special Education Centre in Mrowla in the Podkarpacie country and made use of the Ozierecki test. The level of the mental retardation of the test subjects was either moderate or substantial. The classification of the motor skills of the tested individuals was based on the work by Barański. According to the test results, the children with substantial mental retardation had more difficulties in performing the tasks. These children were most impaired with respect to the speed and precision of their reactions.

Keywords: Abilities, motor skills, mental retardation.

INTRODUCTION

To maintain an optimal level of physical and mental fitness is one of the elementary needs of a human being, especially under the circumstances of our civilisation. Shaping and perfecting motor activities is of particular importance in the case of people with disabilities, including mentally disadvantaged people. This type of disability occurs in every society and its incidence oscillates around 2–3% of the human population (Eider, 1988; Kościelska, 1995; Lausch-Żuk, 1999; Wyczesany, 1999).

Mental retardation involves two main aspects: one of them is prevention, regardless of origin, the other is related to the improvement of an already existing mental disability condition (Clarke & Clarke, 1971; Lausch-Żuk, 1999).

The most important mental feature common to all the mentally retarded individuals is an intelligence level below the standard. However, this insufficiency of the intellect is not the only difference between normal and impaired individuals. Very frequently – although not always – such individuals show a difference in respect to body height and weight, psycho-motor skills, way of thinking, temperament, as well as other mental functions (Clarke & Clarke, 1971; Doroszewska, 1989; Lausch-Żuk, 1999; Olechnowicz, 1994; Polkowska, 1994). In the literature concerned with this subject, there are titles whose authors most frequently compare the physical qualities of normal individuals with those of individuals with a small degree of mental disability (Clarke & Clarke, 1971). However, studies of more seriously incapacitated children are not so numerous, which may result from the substantial difficulties with the organisation of such studies. Seriously retarded children very frequently show deep distrust towards unknown people. The high level of concentration disorders while performing the required tasks constitutes a substantial obstacle to conducting any research.

Although motor skills in mentally impaired people were studied as early as before the First World War, not much research has been conducted in this field for the last 30 years (Clarke & Clarke, 1971; Mleczkowska & Frańczak, 1968; Wyczesany, 1999).

Following an analysis of various tests intended for motor skills assessment, the modified Ozierecki scale seems to be the most appropriate to the subject. This scale makes it easier to diagnose neurological and motor disorders, as well as making it possible to determine the current development level of motor skills in the individual examined (Barański, 1963; Clarke & Clarke, 1971; Mleczkowska & Frańczak, 1968).

The objective of this paper is to determine the motor aptitude of children with a serious mental disability and to find out whether pedagogical forecasts may be generated on the basis of the degree of the development of their motor skills.

RESEARCH MATERIALS AND METHODS

The examinations of the motor skills in mentally retarded children were conducted in the Special School and Upbringing Centre in Mrowla near Rzeszów. The research comprised 49 people aged 10–16, including

TABLE 1
General characteristics of the research subjects

Sex	N	Age [years]							Age [x]	Level of mental retardation					
										mild		moderate		severe	
		10	11	12	13	14	15	16		N	%	N	%	N	%
Girls	21	0	1	4	8	2	4	2	13.47	1	4.76	15	71.42	5	21.80
Boys	28	1	4	6	3	7	3	4	13.46	1	3.57	23	82.14	4	14.28

21 girls and 28 boys. This group was subdivided into three subgroups. The 1st subgroup comprised those with a mild level of mental retardation; the 2nd subgroup – those with a moderate level; the 3rd subgroup – those with a severe level of mental retardation (TABLE 1). Some of the children also have various dysfunctions in their motor organs (scoliosis, paraplegia, hemiplegia, torticollis, club-foot), but in most cases (85.7%) mental retardation was the only observed dysfunction (TABLE 2).

TABLE 2
Dysfunctions in motor organs

Sex	Mental retardation			
	With dysfunctions		Without dysfunctions	
	N	%	N	%
Girls	5	23.8	16	76.2
Boys	2	7.1	26	92.9

The Special School and Upbringing Centre in Mrowla near Rzeszów can ensure good conditions for helping children to achieve suitable motor skills comparable to those of others. There are two halls: one gym and one for correction exercise, and two fields: one for sport and one for recreation where physical education training is held 3–4 times a week and corrective gym training is also held (4 hours per week). Children also have the opportunity to participate in training in the swimming pool 2 hours per week. All examined children attend sporting exercises that improve their motor skills (Momola & Marszałek, 1997).

The examinations were carried out in the correction exercise gym, separately for each individual child. The examination was interrupted in case of the physical or mental tiredness of a given child.

Tests of motor ability were prepared according to the Ozierecki method with a Barański modification. The exercise set for a given calendar age, from 4–16 years of age, included 6 groups of different motor tasks:

- static co-ordination,
- dynamic co-ordination,
- hand co-ordination,
- movement speed,
- simultaneous movement performance,
- movement precision.

The set of tests was held separately in each group. The number of tasks is large and their level of difficulties increases with age and that makes the comparison between age groups difficult and the examination time-consuming.

The evaluation is based on pointing out the age group in which the child completes all tasks and those in which the child doesn't complete any of them. Thus the range of "motor ability" can be estimated and later on–according to special rules – the "motor ability age" can be estimated. Based on the Barański classification one can say whether the child is at a normal level of development, backwardness or precociousness in comparison with the whole population.

The basis for starting the test is estimation of a registered calendar age – that is the difference between the date of research and the date of birth. The next step is – knowing the motor ability age and basis for conducted tasks – an estimation of the difference between the registered and motor ability age that lets us classify the child into one of the following categories:

- precociousness [+D, +C, +B, +A],
- backwardness [–A, –B, –C, –D],
- the norm [0].

The norm of motor skills is the difference between the registered calendar age and the motor ability age and varies from 0 to +18 months. In case the difference is greater than +18 months, motor skills are classified at the precocious development level. In case the difference is below 0 one can say that this is backwardness of motor skills (Barański, 1963; Olszowski, 1973; Szopa, Mleczko, & Żak, 1996).

RESEARCH RESULTS AND DISCUSSION

On the basis of the examinations conducted, the motor skills index in the 1st subgroup was determined to amount to –24 months in a girl, and –60 months in a boy. It must be mentioned that the boy's result may have been influenced by his excessive obesity (his body weight was 96 kg at the body height of 145 cm).

The 2nd subgroup, in which 71% of the girls were characterised by a moderate degree of mental retardation, showed the average motor skills index of –57 months. The participation of boys in this group was

TABLE 3
Results of research on motor skills of children with mental retardation (according to Baranski)

Sex	Level of mental retardation	N	Calendar age [x]	Motor skill development index–MSDI* [months]	Level of motor skill development	Symbol
	Mild	1	12.00	–24	Moderate level of retardation	–B
Girls	Moderate	15	13.73	–57	Very high level of retardation	–D
	Severe	1	11.00	–72	Very high level of retardation	–D
		4	13.50	–	Measureless	–
	Mild	1	13.00	–60	Very high level of retardation	–D
Boys	Moderate	23	13.69	–51	Very high level of retardation	–D
	Severe	4	12.25	–	Measureless	–

MSDI – the difference between motor skills age and calendar age

greater by 11.72%, whereas the average index amounted to –51 months.

The 3rd group consisted of seriously impaired children, including 21% girls and 14% boys. In this group, only one girl managed to complete a test for 5-year-olds, and single tasks for 6-, 7-, and 8-year-olds. The motor skills index for this child was –72 months. The other children in this subgroup were able to complete only single motion tasks in a test, hence they did not reach the level of the motor skills development characteristic of a 4-year-old child (TABLE 3).

An analysis of the degree of acceleration or retardation of motor skills in more seriously impaired children points to a very high level of retardation. In light of the results obtained, the requirements of the Ozierecki scale seem to be too difficult for children with a substantial level of mental incapacity.

Moreover, the research results served the purpose of determination of the difficulty degree while performing respective tests. The easiest of the tests proved to be Test 2, evaluating dynamic hand co-ordination. The second easiest was Test 1, evaluating static co-ordination. Test 3, evaluating the level of whole body co-ordination, proved to be more difficult. The most difficult tasks to complete of those required were, consecutively, the following: Test 4, evaluating the speed of movements, Test 5, of simultaneous movement performance, and Test 6, which evaluated movement precision. The obtained degree of difficulty in performing the tests points to the necessity for more lax requirements while performing tasks for the purpose of the assessment of precision and speed of movements, as well as simultaneous movement performance. The above-mentioned observations concerning the degree of the difficulty of respective tests prove the results of the research by Eider (1988).

Examinations – with the use of the Ozierecki test, as modified by Barański – of the motor skills in children with neurotic disorders, were conducted by Mleczkowska and Frańczak (1968). They claim that 28% of the children examined showed retardation of motor skills development.

The level of physical development of children with a partial loss of sight was studied by Pielecki (1994). Acceleration of motor skills development was not found in those children. The majority of the children were characterised by a moderate level of motor skills retardation, whereas the least frequent disorders were those of movement precision, in contrast to the examination results obtained in more seriously impaired children.

CONCLUSIONS

1. The Ozierecki scale offers a very high degree of difficulty for children with substantial mental retardation.
2. Despite the difficulties in performing the test, motor skills in children with slight mental incapacity should be developed.
3. Children with a substantial mental disability show a very high level of motor skills retardation. In this group, the most disturbed are movement precision and speed, as well as the ability to perform simultaneous movements.

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MOTORICKÉ DOVEDNOSTI U MENTÁLNĚ RETARDOVANÝCH DĚTÍ

(Souhrn anglického textu)

Definice vlohy bere v úvahu funkční efektivitu, kvalitu a rychlost reakcí pozorovanou u jednotlivce. Osobní vloha zahrnuje určité schopnosti, které jsou částečně geneticky podmíněny. Rozsah a úroveň těchto schopností je u jednotlivců rozdílná. Globální schopnosti jsou důležité pro přežití a vývoj jednotlivce, kdežto jednotlivé schopnosti jsou rozhodující pro určení individuality jedince, a to jak fyzické, tak psychologické. Výzkum, jehož výsledky jsou popsány v této práci, zdůrazňuje motorické dovednosti mentálně retardovaných dětí. Výzkum byl proveden mezi 49 dětmi ve věku od 10 do 19 let, které navštěvují Speciální vzdělávací centrum v Mrowle v kraji polské Podkarpacie, a využil Ozereckého test. Úroveň mentální retardace testovaných subjektů byla buď mírná nebo střední. Klasifikace motorických dovedností testovaných jednotlivců byla založena na práci Barańského. Vzhledem k výsledkům testu měly děti s hlubší mentální retardací větší problémy provést úkoly. Tyto děti dosáhly horších výsledků, byly hodně slabší s ohledem na přesnost a rychlost jejich reakce.

Klíčová slova: schopnosti, motorické dovednosti, mentální retardace.

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PROGRAMMED LEARNING IN THE PROCESS OF MOTOR LEARNING

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Programmed learning is a specified learning procedure with its material organized into sequences and little units (Dembo, 1997). In education, programmed learning serves to facilitate learning in a school class, for it allows for the presentation of even the most difficult issues in little portions, and students may acquire them at their own pace (Kruszewski, 1972). The aim of the present work was to define motor effects in the process of learning new motor activities with the use of two different forms of programmed learning in conjunction with other methods: a linear program for learning "juggling with balls" connected with the analytic method (learning by parts) – a chart (large scale illustration) program (Wieczorek, 1999) and a branched program for learning "the Tai-chi system" connected with a synthetic method (whole learning/learning by wholes) – computer-aided programmed learning (Guła-Kubiszewska, 2000). Research was carried out among adults – altogether 183 people (3 groups). The average age was 19–24 years. We obtained, in our research, positive results, indicatiing the high effectiveness of this method in the process of motor activity learning and teaching. In the three groups, an average level of mastering a new motor activity prevails, which may be interpreted as a very satisfactory result for more than half of the learners who achieved the planned result. This was the group, in which the program for learning a new motor activity not only gave us some feedback on the execution level, it was a computer-aided program, which confirmed the thesis on the possibility of a more effective use in it of regularities which constitute the basis of programmed learning (Dembo, 1997).

Keywords: Motor learning, programmed learning.

INTRODUCTION

Programmed learning is a specified learning procedure with its material organized into sequences and little units (Dembo, 1997). It acts as a self-education set which presents its material in a carefully-planned order and requires reacting through gap-filling and choosing answers by students. Each answer is followed by immediate feedback. Programmed learning is used most frequently as a linear or branched program.

In a linear program the material is presented in such a manner so that all students would familiarize themselves with the program in the same order. In a branched program the programmed material includes numerous and varied possibilities of going through the content.

In education, programmed learning serves to facilitate learning in a school class, for it allows to present even the most difficult issues in little portions, and students may acquire them at their rate. In such form of teaching, the teacher, via the program, may give the learning activity the desired structure and direction; into this structure, the teacher introduces changes which guarantee previously empirically defined high and relatively permanent probability of achieving planned results by students (Kruszewski, 1972).

A program is a task giving the activity of learning a defined structure. The structure consists of elementary tasks the system of which, established or changing according to a set of rules, assures such a direction of the activity of learning so that the planned result would be reached with expected high probability (Kupisiewicz, 1991; Kruszewski, 1972; Słomkiewicz, 1972).

Programmed learning represents certain features, vital for the process of education: the material is divided into doses being interconnected as regards essence and logic; students work actively; they may proceed to the next dose after the work with the previous dose has been completed, student's answers are compared with the correct answer; the rate of learning is subject to individualization; the program undergoes empirical verification (to establish its usefulness for a given group of students and to assess the effectiveness of the program).

According to Rothrock (Dembo, 1997), research on programmed learning did not give any positive results, for it did not fulfill the hopes placed in it. Computer-aided teaching turned out to be more effective and still based on those same regularities of learning. A computer plays the role of a teacher since it provides information, and enables students to exercise, evaluates achievements of students, and gives them additional possibilities for learning. Computer-aided teaching gives us an opportunity to use more effectively the regularities which are the basis of programmed learning (Dembo, 1997).

Programmed learning was especially accepted in relation to more theoretical subjects, however, between 1969 and 1970, the possibilities of using this method in the process of physical education began to be studied. Motor tasks which are the object of learning are presented by the use of a properly-prepared program (booklets and boards with relevant instructions). The program for learning a new motor activity/function is a precisely-ordered linear sequence of methodical exercises and activities leading via the shortest way towards mastering new movement skills (Strzyżewski, 1986). The program is equipped with objects playing the role of a regulator of movements produced by exercising students and a measure of a well- or badly- done motor task. They allow students an individual assessment of their work directly after completion of an exercise and the adequate management of further steps in the course of learning.

The most widespread form of programmed learning in physical education are programmed cards (Czabański, 1991; Czabański & Guła-Kubiszewska, 1993; Wieczorek, 1999). One should separate subsequent sensomotoric sequences within the motor activity which is being taught and then present them in a graphic form with verbal instruction. Often, programmed teaching is employed in conjunction with other methods (e.g. in Germany and Austria).

The aim of the present work was to define motor effects in the process of learning new motor activities with the use of two different forms of programmed learning in conjunction with other methods:

1. A linear program for learning "juggling with balls" connected with the analytic method (learning by parts) – a chart (large scale illustration) program (Wieczorek, 1999).
2. A branched program for learning "the Tai-chi system" connected with a synthetic method (whole learning/learning by wholes) – computer-aided programmed learning (Guła-Kubiszewska, 2000).

In the linear program, developed as large-scale illustrations (charts), students engage in self-regulating activities after each step and they receive feedback on the level of execution of a given motor sequence without delay. In the computer-aided program self-regulating activities are connected with regulation of the representation of a plan and program of a motor activity.

The received feedback informs the learner about the precision of representation of the course of movement, whereas a motor activity is performed as a whole. The executive control allows further facilitation of motor representation programming. In programmed learning, Internal Programming Strategy was employed in the form of a cognitive strategy as well as a metacognitive one (Guła-Kubiszewska, 2002).

The following research questions have been formulated:

1. What level of motor effects has been reached by the use of the classic programmed learning and computer-aided teaching?
2. Was the manner of performing executive control (whole or part) related to the effectiveness of motor learning?

MATERIAL AND METHODS OF RESEARCH

Research was carried out in the years 2000–2003 among: the soldiers of Basic Military Service in Koszalin (60 people), female students of Higher Vocational School in Legnica as well as the employees of DPS Dom Pomocy Społecznej [Social Assistance Home] in Legnickie Pole (30 people) as well as students of the first year of Wrocław University School of Physical Education (group I – 46 people, group II – 47 people). The average age of both groups was 19–24 years.

The method of research was the pedagogical experiment. The examined learners after having familiarized themselves with the aim of learning as well as having performed motivational activities encouraging learning took up activities in compliance with the foundations of the program. They took the decision concerning the completion of learning on their own.

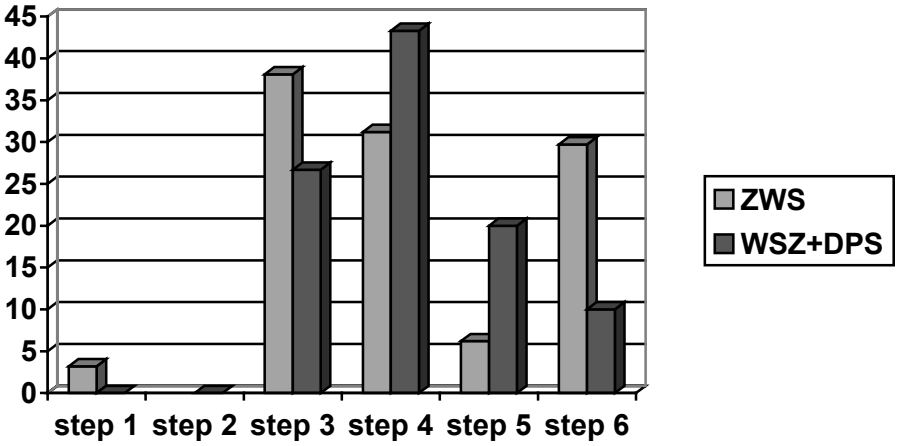
RESULTS

In the process of motor learning using the classic programmed learning, motor effects were measured by the number of steps which the examined learners mastered over the course of time. The other measure – called the Learning Speed Index (LSI) – was calculated based upon the rate of increase of skills in the subsequent stages of learning (Wieczorek, 1998).

This value is proportional to the area under the curve of learning, where on the axis of ordinates the next steps of learning have been marked and on the axis of abscissae where the next stages of learning have been marked. This enables the division of the learning students into groups of slow, medium and fast rate result increase.

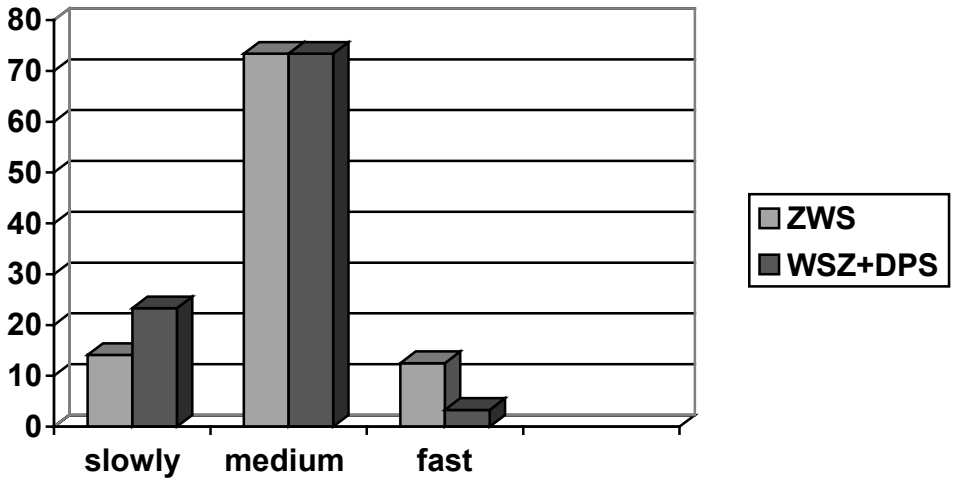
Among the examined soldiers the highest percentage was reached as regards step three (38.1%) and step four (31.2%). Of the examined soldiers, 29.7% were completely successful in learning, meaning that step six was achieved. Within the group of female students and employees the scope of mastering the program is very similar. Most of the examined learners mastered the motor activity at the level of step four (43.3%) and step three (26.7%). Only 10% of the examined learners mastered the motor task well, however the soldiers obtained better effects of learning a motor activity (Fig. 1).

Fig. 1
Percentage of the level relating to mastering the program by the examined learners (effects)



(ZWS – soldiers, WSZ+DPS – female, students and employees)

Fig. 2
Percentage of motor learning speed (based on LSI) achieved by the examined learners



(ZWS – soldiers, WSZ+DPS – female, students and employees)

Almost 3/4 (73.4%) of the examined soldiers mastered a new motor activity which resulted in an increase in motor learning at a medium level. The maximum limit of executing the activity for themselves was reached; at a fast rate – only 12.5% of the examined soldiers, similarly to the group of slow-learners (14.1%).

Also almost 3/4 of the examined female students of the Higher Vocational School (WSZ) as well as the employees of the Social Assistance Home (DPS) (73.4%) reached their optimum level of task execution indicating a medium level of motor effects increase. Of the examined learners, 23.3% were fast learners, whereas only 3.3% learned slowly (Fig. 2).

To sum up the effectiveness of motor learning by employing classic programmed learning, one can state that the examined groups reached mainly a medium level of learning effects at an average rate of result increase.

By using r-Pearson's test the correlation between the achieved step of the program (learning effect) and the speed of learning (WSU/ LSI) for & = 0.05 was shown.

Within the group of examined female students of the University School of Physical Education in Wrocław

Fig. 3
Percentage of regulating activities level among students of the University School of Physical Education in Wrocław

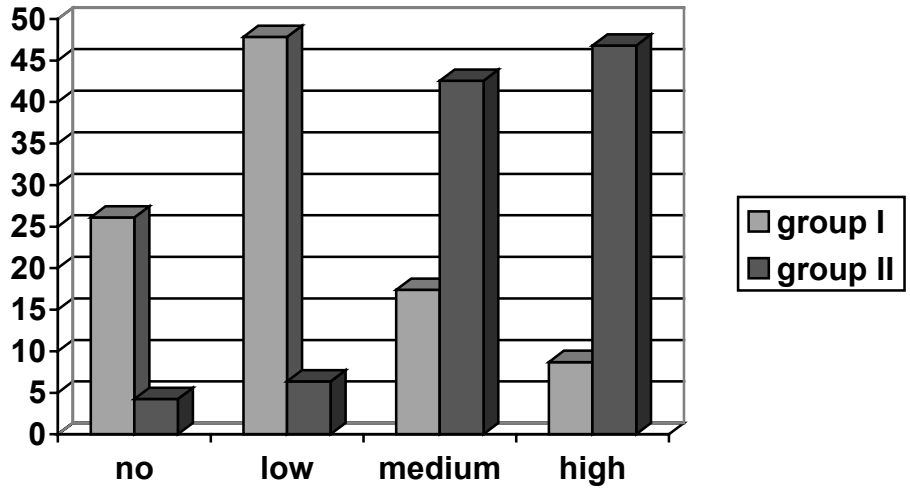
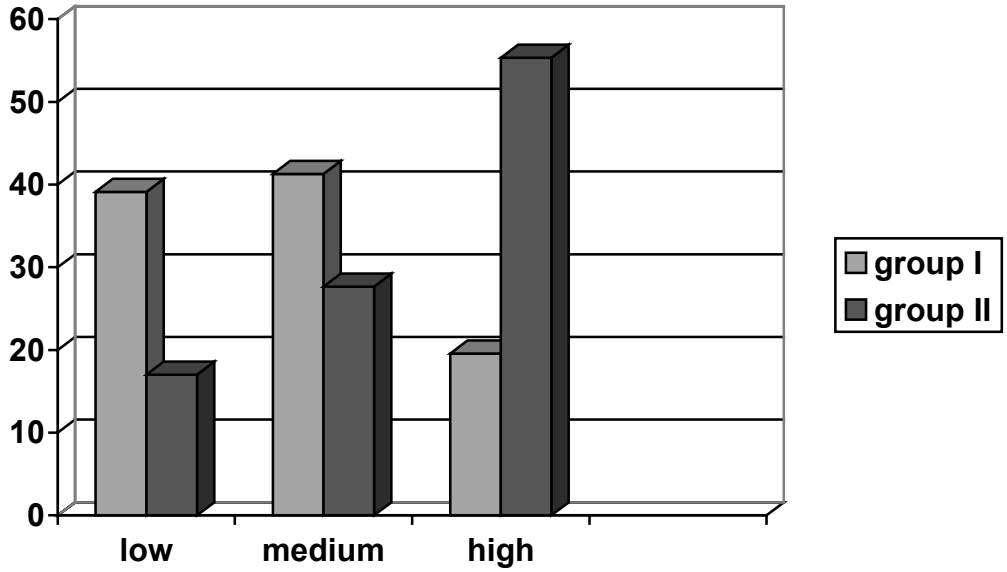


Fig. 4
Percentage of motor learning effectiveness level among the students of University School of Physical Education in Wrocław



where computer-aided motor learning was employed, learning effects were assessed on the basis of the level of mastering a new motor task as well as by the level of regulating activities. Group I followed the program which aimed at learning through programming of motor representation, whereas group II through self-regulation of the representation. The executive control related to the whole execution (execution by wholes) of activities provided new information which again supported regulating activities of the motor representation.

Within the group of students programming motor representation a low level of these activities (47.82% of the examined) or lack of such activities (26.09%) prevails. Only 35% of the examined learners executed regulation programming activities at a higher level: 17.39% at a medium level and 8.70% at a high level.

The situation was different in the group of examined learners who used motor representation in a self-regulating skills developing program. Almost half of the examined learners reached a high level (46.80%), similarly to a medium level (42.56% of the examined). Approximately 10% of the examined learners did not program any self-regulating activities (low level 6.38% and 4.26% none) (Fig. 3).

In the first group examined learners mastered a new motor activity mainly at an average level (41.30%). Only 19.57% of the examined students succeeded in mastering the new motor skill, and 39.13% did not master this skill. Some very good effects of motor learning may be observed in the second group. More than half of the examined students learned a new motor activity very well (55.32%), 1/4 well (27.66%), whereas only 17.02% did not master the new task (Fig. 4).

The Pearson Chi Square Test ($p = 0.00$) and Chi Square of Highest Credibility ($p = 0.00$) for $\& = 0.05$ showed that dependencies exist between the level of self-regulation and the effectiveness of motor learning. The higher the self-regulating control, the better command of a motor task there is.

SUMMARY AND CONCLUSIONS

Numerous experimental investigations concerning the use of programmed learning in physical education practice usually showed positive results, which indicates the high effectiveness of this method in the process of motor activity learning and teaching (Strzyżewski, 1986; Czabański, 1991; Nowak, 1985, 1989).

The results obtained in our research partly confirm this assumption. In the three groups, an average level of mastering a new motor activity prevails, which may be interpreted as a very satisfactory result for more than half of the learners who achieved the planned result. This was the group, in which the program for learning a new motor activity not only provided some feedback on the execution level, but also it stimulated self-regulating activities as an element of the learning program. Additionally, it was a computer-aided program, which confirmed the thesis on the possibility of a more effective use in it of regularities which constitute the basis of programmed learning (Dembo, 1997).

CONCLUSION

1. The use of programmed learning in the process of motor learning in both a classic and computer-aided form results in similar didactic effects when the structure of the program is focused on mastering the taught content.
2. The best results were achieved in computer-aided learning when the structure of the program developed regulating skills of the learner.
3. The manner of executive control in the form of learning by wholes (whole learning) or learning by parts (partial learning) did not directly show effects of motor learning.

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PROGRAMOVANÉ UČENÍ V PROCESU MOTORICKÉHO UČENÍ

(Souhrn anglického textu)

Programované učení je specifický postup učení s materiály, které jsou posloupně uspořádány do malých jednotek (Dembo, 1997). Ve vyučování programované učení slouží k usnadnění výuky ve školní třídě, protože dovoluje prezentovat dokonce i nejtěžší učivo v malých dávkách a studenti si je mohou osvojit podle svého tempa (Kruszewski, 1972). Cílem předložené práce bylo určit motorické výsledky v procesu učení nových

motorických akivit s použitím dvou rozdílných forem programovaného učení ve spojení s dalšími metodami: lineární program na učení "žoglování s balónky" spojený s analytickou metodou (učení po částech) – tabulkový program (ilustrace velkého formátu) (Wieczorek, 1999) a odborný program na učení "Tai-chi systém" spojený se syntetickou metodou (učení po celcích) – programované učení pomocí počítače (Guła-Kubiszewska, 2000). Výzkum byl proveden mezi 183 dospělými lidmi (3 skupiny). Průměrný věk byl 19–24 let.

Výsledky získané v našem výzkumu ukázaly pozitivní výsledky, které dokazují vysokou efektivitu této metody v procesu vyučování a učení motorických aktivit. Ve třech skupinách převažuje průměrná úroveň zvládnutí nových motorických činností, což můžeme interpretovat jako velmi uspokojivý výsledek, protože více než polovina zúčastněných členů dosáhla plánovaných výsledků. Toto byla skupina, ve které program na učení nových motorických aktivit nejenom že dal nějakou zpětnou vazbu na úrovni provedení, ale byl to program tzv. programovaného učení pomocí počítače, který potvrdil hypotézy o svých možnostech při efektivnějším a pravidelném používání, což stanoví základy pro programované učení (Dembo, 1977).

Klíčová slova: motorické učení, programované učení.

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First-line publication

The self-regulation process of a motoric learning.

INSTRUCTIONS FOR MANUSCRIPT FOR THE ACTA UPO GYMNICA

The magazine Acta Universitatis Palackianae Olomucensis Gymnica is an independent professional magazine. 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 on a diskette 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.

Tables, pictures, graphs, appendices

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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4th International Conference on Movement and Health
Preliminary Information

Welcome!
The Faculty of Physical Culture is hosting, for the 4th time so far, the international conference called Movement and Health, which has already become a tradition. Every two years scientific workers and the scholarly public meet in order to discuss issues for which the common denominator is the term health in relation to human movement activity. Evolutionary trends leading to the continuous decrease in the amount and intensity of movement in human lives should warn us and the solution of these problems represents, from the point of view of the entire society, a serious health, social and economic difficulty. If you are interested in the issue to which we are referring, your participation in our conference will provide you with a very broad and deep look into the many-faceted complex of questions having to do with our central theme. The traditionally high-quality and hospitable atmosphere of conference proceedings at our Faculty, together with the architectural and historical attractiveness of Olomouc, all of this combines to create an intricate framework for the pleasant and scientifically interesting atmosphere to which our regular participants gladly and repeatedly return. We are looking forward to seeing everybody, both those who have participated in the past as well as newcomers and we will be very glad to welcome you to Olomouc.

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- Social, philosophical and psychological determinants of life style
- Biomechanical and physiotherapeutical aspects of the human movement system
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- Physical activities in school
- Quality of life and sport activities of persons with special needs
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- Management and marketing of sport and physical activities
- Research methods in physical activities

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Date
November 23–25, 2005

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Czech, English, Polish, Slovak
Presentation will be published in English in the conference proceedings.

Forms of presentation
keynote lecture, oral, poster, workshop

Conference fee
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The conference fees cover all academic activities, refreshments during the conference, proceedings and social programme.

Important dates
October 2004, First Announcement
January 2005, Deadline for abstract submission
March 2005, Notification to authors
May 2005, Application and conference fee
July 2005, Deadline for papers submission
September 2005, Second Announcement

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