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JUMP ERGOMETER IN SPORT PERFORMANCE TESTING

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Submitted in September, 2004

The papers deals with the application of the jump ergometer in the evaluation of neuromuscular performance. Altogether 288 athletes of different sport specializations (mean age 18.9 ± 6.4 years, height 172.2 ± 4.3 cm, and weight 62.4 ± 4.9 kg) underwent various tests on the jump ergometer, such as 10-, 60-, and 90-second repeated jumps, squat and countermovement jumps without and with an additional load, and drop jumps from different heights with and without bending the knees. The diagnostic system FiTRO Jumper consisting of a special contact switch mattress connected by means of an interface to a computer was used. Jump parameters (power in the active phase of take off and height of the jump) were calculated from the flight and contact times. Results showed that the system may be applied for the assessment of explosive power of the lower extremities, strength endurance of the lower extremities, utilization of the stretch shortening cycle, distribution of fast twitch fibers, optimal drop jump height for plyometric training, and training effects, namely in sports such as basketball, volleyball, soccer, tennis, gymnastics, rock and roll, figure skating, track and field, ski jumping, weight lifting, etc.

Keywords: Explosive power, jump ergometer, sport performance testing.

INTRODUCTION

Explosive power influences performance in many sports, hence its assessment should be considered as an integral part of functional diagnostics in athletes.

Although the jump ergometer is frequently used for this purpose, there are still a lack of information concerning the possibilities of its application to the evaluation of the actual state of jump abilities, training control and talent identification.

Therefore the aim of the study was to present results and experiences with the utilization of the jump ergometer in sport practice.

MATERIAL AND METHODS

Altogether 288 athletes of different sport specializations (mean age 18.9 ± 6.4 years, height 172.2 ± 4.3 cm, and weight 62.4 ± 4.9 kg) volunteered to participate in the study.

They performed variuos tests on the jump ergometer, such as 10-, 60-, and 90-second repeated jumps, squat and countermovement jumps without and with an additional load, and drop jumps from different heights with and without bending the knees. Each method is described in a particular part of the article, however the details of each have to be found in related references.

The FiTRO Jumper (Fig. 1) consisting of a special contact switch mattress connected by means of a special interface to a computer was used (Hamar, 1991). The system measures contact and flight times (with an accurancy of 1 ms) during serial jumps and calculates basic biomechanical parameters (Fig. 2). The reliability of the test has been proved to be sufficient enough (Tkáč et al., 1990) to be applied to functional diagnostics of athletes.

Fig. 1
FiTRO Jumper – a PC based system for the assessment of the explosive power of the lower extremities

Fig. 2
Jump parameters: tc (s) – contact time, tf (s) – flight time, P' (W/kg) – mean power in the entire jump cycle, P (W/kg) – power in the active phase of the take off, h (cm) – height of the jump, v (m/s) – mean velocity during the concentric phase of the take off, a (m/s^2) – mean acceleration during the concentric phase of the take off

Test No: 1 Age: 18 y Weight: 60 kg Duration of test: 10 seconds
ASSIGMENT: 29.7.2003 Mean frequency: 86/min

RANKING	tc(s)	tf(s)	P(W/kg)	P'(W/kg)	h(cm)	v(m/s)	a(m/(s.s))	h/tc
1	0.202	0.512	39.5	6.16	32.1	2.511	22.69	139.8
2	0.208	0.503	39.5	6.05	31.0	2.467	22.49	138.6
3	0.211	0.490	38.5	5.89	29.4	2.403	22.25	136.4
MEAN	0.207	0.502	39.2	6.03	30.9	2.461	22.48	138.2

RESULTS AND DISCUSSION

The results showed various possibilities of application of the jump ergometer in sport practice.

Distribution of fast twitch fibers

Muscle needle biopsies allowing direct measurement of biochemical parameters of anaerobic metabolism in the working muscle are technically complicated and remain limited to research investigations. Hence, indirect methods are preferred in practice.

There are data in the literature indicating that maximal power production during short term exercise depends on the percentage of fast twitch fibers (Bar-Or et al., 1980; Inbar et al., 1981; Kaczkowski et al., 1982). There is a particularly high correlation (r = 0.860) between the percentage of fast twitch fibers in the vastus lateralis and power in the active phase of the take off (Pact). Similarly, a 15-s jumping test has been reported by Bosco et al. (1983). Such a parameter thus in fact express the capability to take off with the highest intensity, in the shortest time.

Taking this into account it may be assumed that percentile lines of FT distribution in the population will be similar to those of Pact obtained in the jumping test. Thus, the percentile charts of power in the active phase of the take off can be utilized not only for the estimation of explosive power but also for the rough indirect assessment of muscle fiber distribution in the lower extremities. Therefore, population norms available on the FiTRO Jumper system (Hamar & Tkáč, 1995) may also be used for talent identification.

Assessment of the explosive power of the lower extremities

A test of 10-second maximal jumps with the hands fixed on the hips in order to minimize the influence of the upper extremities is used. Three trials with a two minute pause after each are performed while the better score from the last two is taken for evaluation. The most reliable parameter has been found to be power in the active phase of the take off in watts per kg of body weight expressed as the mean of the three maximum values of a jumping sequence (Tkáč et al., 1990).

Values of jump parameters obtained by such a test may be compared with population norms. However, these cannot be applied in athletes who have been, for a long time, exposed to training focused on the development of explosive power, such as, e. g. in rock and roll (Fig. 3) since considerable differences between athletes with different demands on jump abilities have been documented (Hamar, 1991; Fig. 4). Hence, further studies are needed to elaborate specific norms for particular sports.

Fig. 3
Power in the active phase of the take off in rock and roll dancers in comparison with the population (Dzurenková et al., 1999)

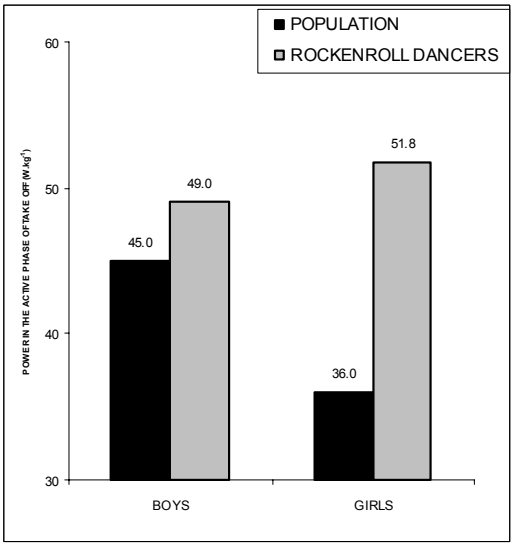
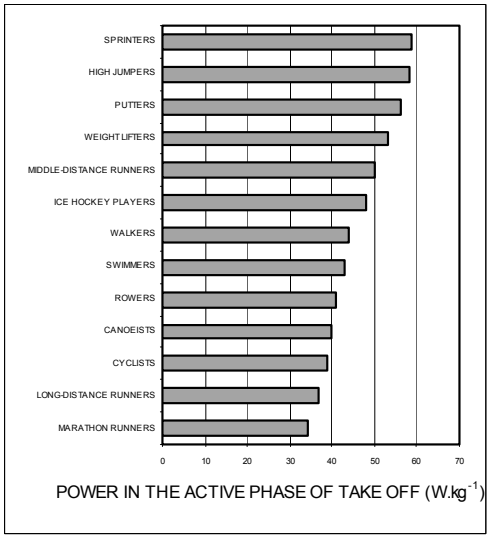


Fig. 4
Power in the active phase of take off in athletes of different specializations (Hamar, 1991)



Assessment of strenghth endurance of the lower extremities

A method of repeated vertical jumps, usually with a duration of 30, 60 or 90 seconds (Bosco et al., 1983; Zemková et al., 1997; Dzurenková et al., 1999, 2000; Zemková et al., 2001, 2002) depending on sport specialization (Fig. 5, 6) is used. In some sports the construction of individual time course curves of the jump parameters is recommended by coaches (Pelikán et al., 1999) in order to compare the specific performance in strength endurance between athletes (Fig. 7, 8).

Besides the qualification of power in the active phase of the take off and the height of the jump, also the fatigue index, expressed as a ratio of power decline (Pmax--Pmin/Pmax), may be calculated.

Fig. 5
Power in the active phase of the take off in a 60-s test on the jump ergometer (karate athletes, n = 18)

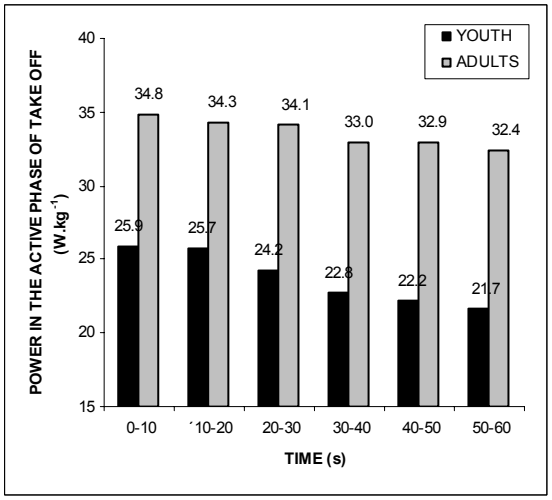


Fig. 6
Power in the active phase of the take off in a 90-s test on the jump ergometer (rock and roll dancers, n = 18)

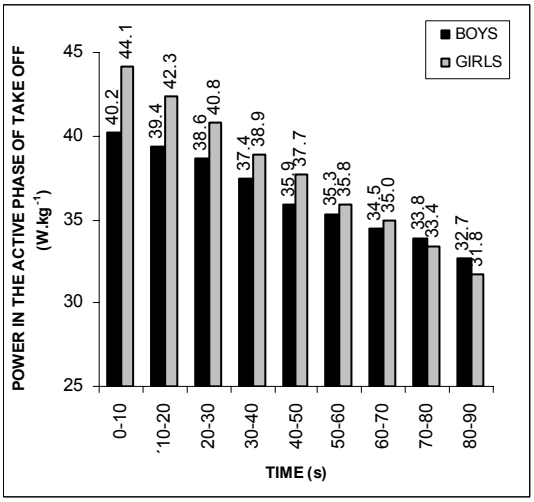
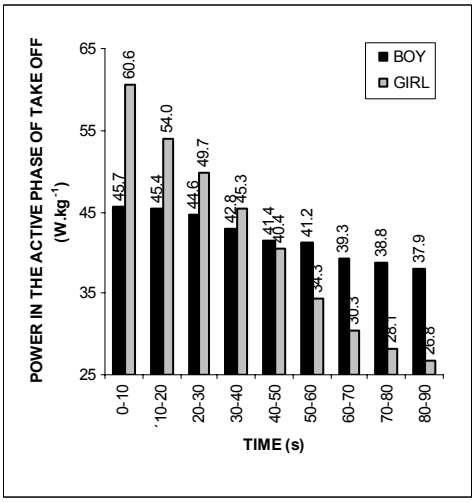
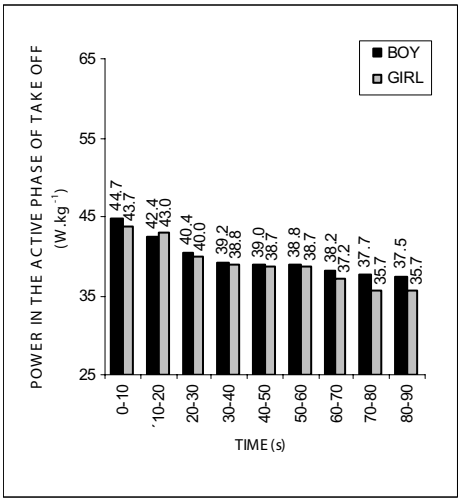


Fig. 7, 8
Power in the active phase of the take off during a 90-s test of repeated jumps in rock and roll dancers (an example of two couples)

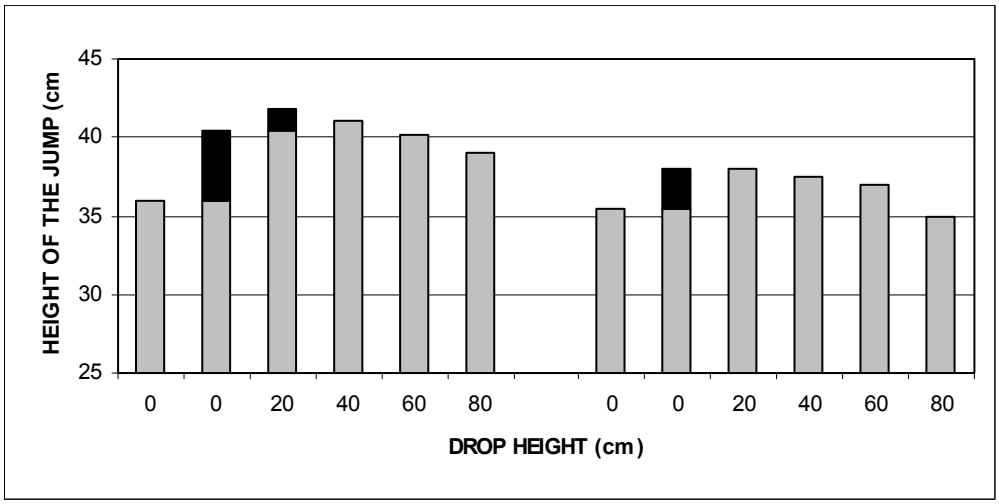




Utilization of elastic energy

It is known that the better ability to utilize elastic energy, the higher the difference between squat and countermovement jumps. Such a difference can be even more pronounced by means of drop jumps from different heights (Fig. 9).

Fig. 9
Squat and countermovement drop jumps from different heights (an example of two athletes with different abilities to utilize elastic energy)



Determination of optimal drop jump height for plyometric training

Plyometric training, which became popular during the late 1970s and early 1980s, has a number of variations, including repetitive jumping on and off a box and jumping while wearing weight belts (Bobbert et al., 1996).

Usually, in random order drop jumps from different heights (with 10 to 20 cm in-between) are performed with the aim of estimating the one from which the highest power is achieved. The individual curve of the relationship between jump parameters and drop height may be then constructed (Fig. 10).

It has been found that the optimal drop jump height for plyometric training is different in athletes of different specializations and expectedly better in those with higher performance in the explosive power of the lower extremities (Fig. 11).

Fig. 10
The power in the acive phase of take off from different drop heights

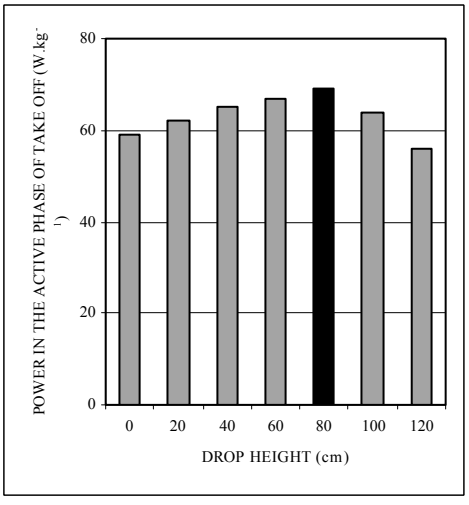


Fig. 11
Height of the drop jump in athletes of different specializations

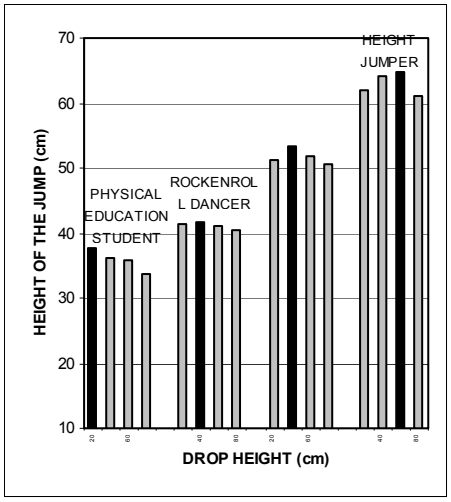
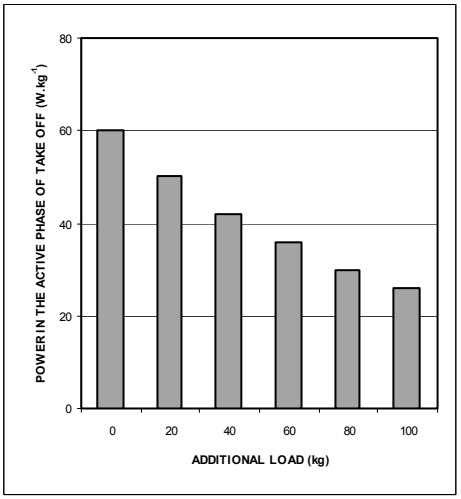


Fig. 12
Power decrease with increased additional load (a barbell across the shoulders)



Differentiation of jump abilities by means of an additional load

Jumps performed with an additional load (Fig. 12) are considered to be a more suitable method for the assessment of the explosive power of the lower extremities in highly skilled athletes since more information about the structure of jump abilities may be obtained.

First, the difference between squat and a countermovement jump is more profound with than without an additional load, depending on the sport specialization (Fig. 13).

Second, such a test has been found (Zemková et al., 2004) to be more sensitive for athletes with high performance in the explosive power of the lower extremities as compared to a general test (Fig. 14). These differences have been observed in physical education students, too (Fig. 15).

Fig. 13
Difference in squat and countermovement drop jumps performed without and with additional load (athletes of different specializations, n = 58)

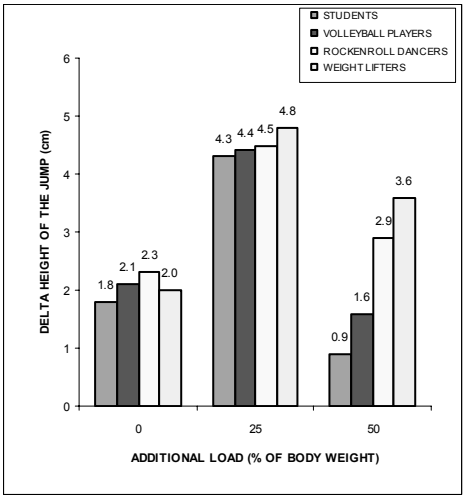
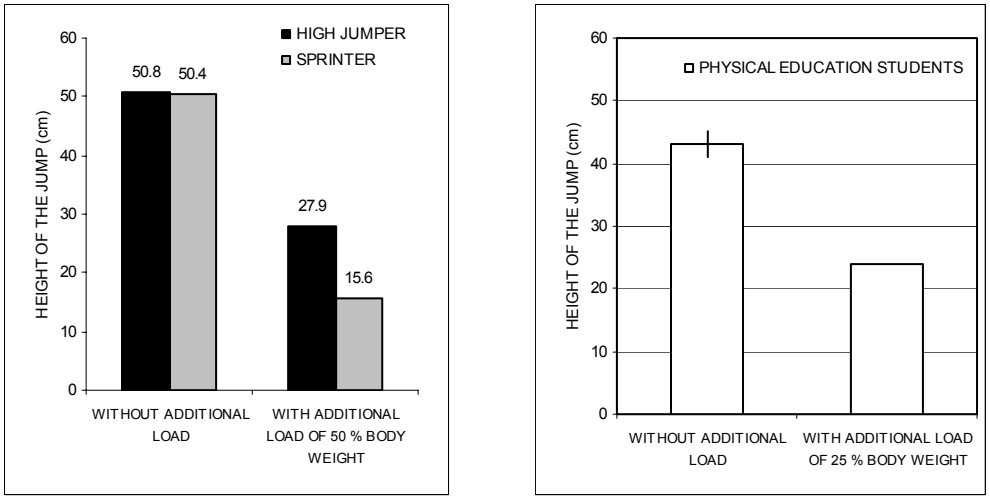


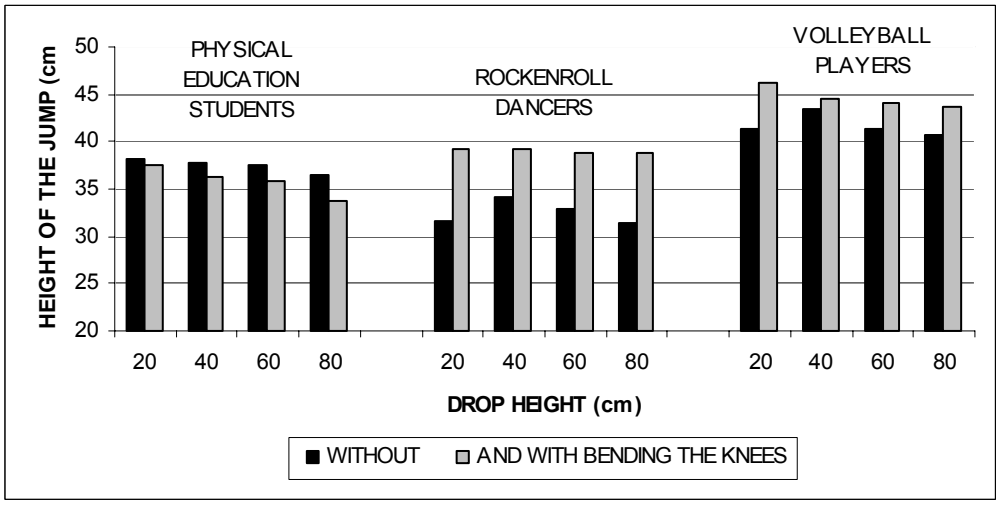
Fig. 14, 15
Squat and countermovement drop jumps without and with an additional load (high jumper and sprinter and 56 physical education students, respectively)



Evaluation of sport specific performance

In some sports (Fig. 16) a test consisting of drop jumps from different heights (performed under two different conditions) may be employed. In the first, subjects are instructed to perform a maximal countermovement jump without bending the knees, in the second they are allowed to bend the knees in an effort to achieve the highest height possible. In both tests they have to hold their hands on their hips in order to minimise the influence of the upper extremities.

Fig. 16
Height of the drop jumps from heights of 20, 40, 60, and 80 cm with and without bending the knees (athletes of different specializations, n = 84)



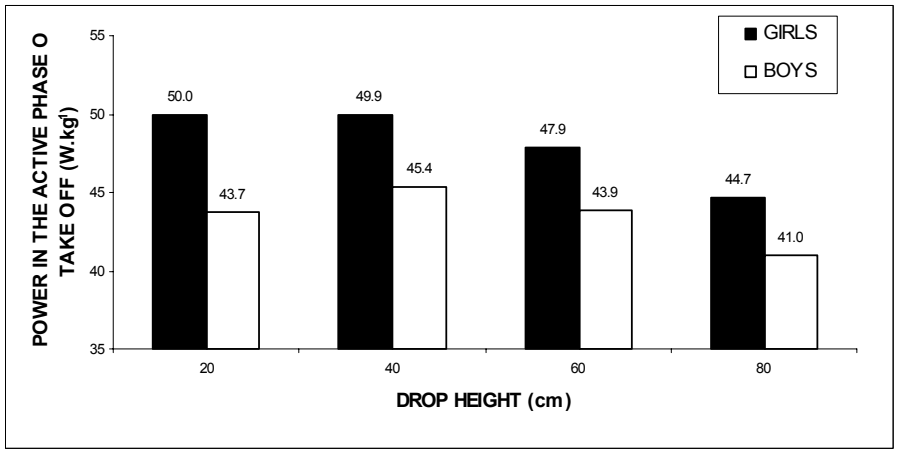
In particular, in rock and roll, it is known from the biomechanical analysis of jumps that girls tend to perform bounces from straight legs while boys jump from bent knees. Tests has been found to reveal this different character of jumping between male and female dancers (Zemková et al., 2001).

It has been shown that boys achieved significantly ($p < 0.01$) higher heights while performing countermovement jumps from bent knees than from straight legs (39.1 ± 0.2 and 32.6 ± 1.2 cm, respectively). This difference can be ascribed to the predominant training stimuli due to countermovement jumping from the lower knee-bent positions.

On the other hand, in girls there were no significant differences between test conditions used (28.1 ± 1.4 and 27.5 ± 1.1 cm, respectively). This is probably because they are performing and training bounces from straight legs. However, they achieved significantly ($p < 0.05$) higher power in the active phase of the take off as compared to boys (Fig. 17).

The better abilities of girls to produce power in the active phase of the take off while performing countermovement jumps from the straight legged position may be attributed to both genetic disposition (a higher share of fast fibers) as well as to the fact that the conditions of muscle work in the test are similar to the predominant female dancing elements of rock and roll.

Fig. 17
Power in the active phase of take off after drop jump from different heights with and without bending the knees (male and female rock and roll dancers, n = 22)



Training control

Evaluation of changes in jump parameters during short or long term training is of special interest in sports like basketball, volleyball, soccer, tennis, gymnastics, rock and roll, figure skating, track and field, ski jumping, weight lifting, etc., in which these abilities particularly influence athletes' performance. Such examples are given (Fig. 18, 19, 20, 21). Different methods, described above, were used to evaluate the specific performance of the examined athletes.

Fig. 18
Differences in the height of the countermovement and squat jumps without and with an additional load of 25, 50, 75, and 100% of body weight in weightlifters prior to and after three months of special training aimed at national competition in comparison with recreational athletes.

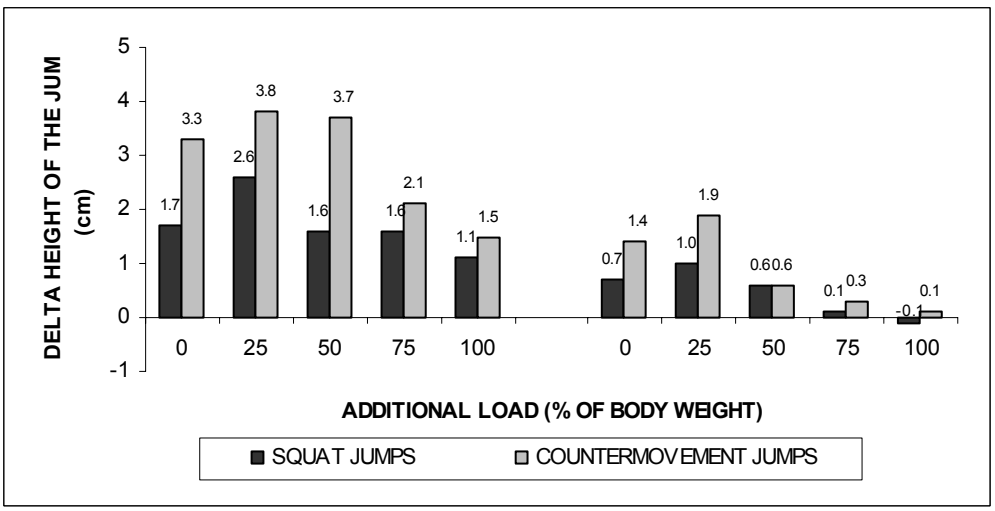


Fig. 19
Height of drop jumps from heights of 20, 40, 60, and 80 cm performed without and with bending the knees prior to and after one year of training in volleyball players (n = 8)

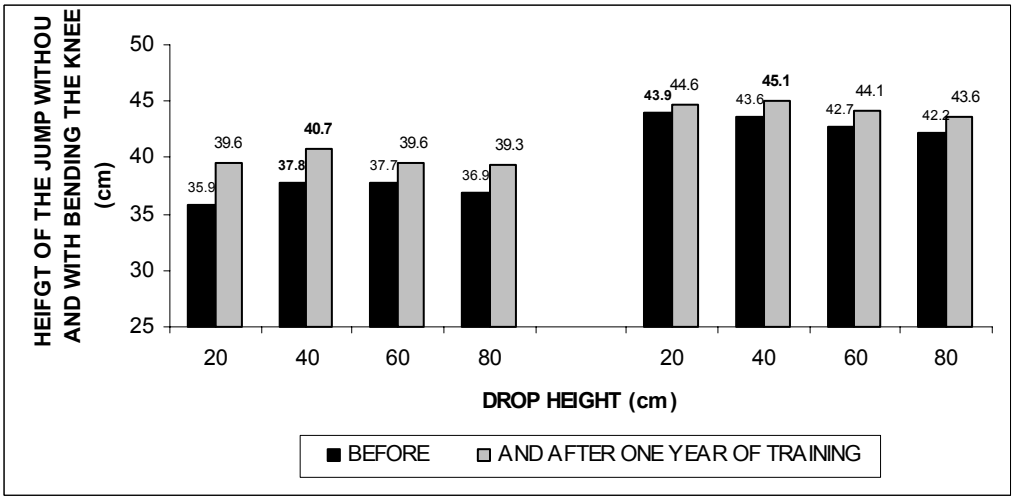
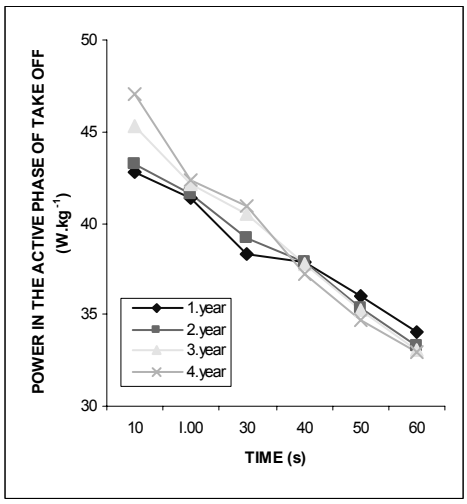
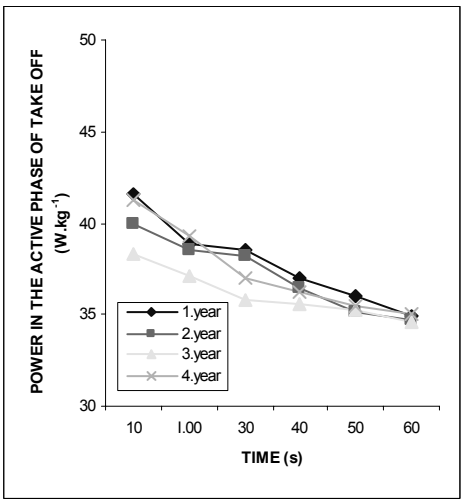


Fig. 20, 21
Power in the active phase of the take off in a 60-second test on the jump ergometer during four years of training in female and male rock and roll dancers (n = 10) (Dzurenková et al., 2001; Zemková et al., 2003)





CONCLUSION

Based on the results obtained and experiences gained with the application of the jump ergometer in the assessment of neuromuscular performance in athletes of various specializations it may be concluded that such a system helps with talent identification, the differentiation of athletes with different age and performance levels as well as evaluation of the effect of training focused on the improvement of jumping abilities.

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VÝSKOKOVÝ ERGOMETR V DIAGNOSTICE SPORTOVNÍ VÝKONNOSTI

(Souhrn anglického textu)

Práce poukazuje na možnosti uplatnění výskokového ergometru při posuzovaní odrazových schopností dolních končetin. Celkem 288 sportovců s různou specializací (průměrný věk 18,9 ± 6,4 let, výška 172,2 ± 4,3 cm, hmotnost 62,4 ± 4,9 kg) absolvovalo testy na výskokovém ergometru, a to 10, 60 a 90sekundový test opakovaných snožných výskoků, výskoky bez a s protipohybem s hmotností vlastního těla, resp. s dodatečnou váhou, jakož i seskoky z různych výšek do rovných, resp. pokrčených dolních končetin. Parametry odrazových schopností (výkon v aktivní fázi odrazu a výška výskoku) byly registrovány pomocí diagnostického systému FiTRO Jumper sestávajícího z odrazové doby napojené prostřednictvím interfejsu na počítač. Výsledky ukázaly, že toto zařízení je možné využívat při výběru talentů, posuzovaní aktuálního stavu výbušné síly dolních končetin, odrazové vytrvalosti dolních končetin, určení individuální optimální výšky seskoku pro plyometrický trénink, zvláštnosti odrazových schopností v jednotlivých sportech, schopnosti využívat elastickou energii, diferenciaci odrazových schopností pomocí dodatečné váhy a změny těchto schopností v průběhu sportovní

přípravy, čímž pomáhá objektivizovat efekt tréninku speciálně zaměřeného na jejich rozvoj.

Klíčová slova: diagnostika trénovanosti, odrazová výbušnost, výskokový ergometr.

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EFFECT OF REGULAR TRAINING ON BODY COMPOSITION AND PHYSICAL PERFORMANCE IN YOUNG CROSS-COUNTRY SKIERS: AS COMPARED WITH NORMAL CONTROLS

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The aim of this study was to determine body composition parameters and level of physical performance together with evaluation of changes in body composition and in the level of physical performance under the influence of regular training performed during a preparatory training period in a group of young cross-country skiers (both genders), pupils of sport primary school, and the participants of ski-clubs between the ages of 12–15 years (n = 81), as compared with normal controls (n = 49). The multi-frequency BIA method (B. I. A. 2000M, Data Input, Germany) was used for determination of body composition. The level of physical performance was estimated through basic motor tests. Results from the present study indicate the positive effect of systematic regular training performed through the special cross-country skiing sport primary school. Firstly for cultivation of young elite cross-country skiers, resp. sport talents for high performance, and secondly as a factor influencing the body composition and the level of physical performance in children and youth with regular physical activity via ultra physical education lessons. Regular cross-country skiing training seems to be favorably influenced by BC related to physical performance in children and youth. Hence, regular training functions also as a means of prevention of overweight or obesity-affected health and psychological, social, economic and other complications in youth, as in those of adult age. The results from this study can provide valuable feedback affecting the improving of training preparation of the followed subjects as well as the enriching of the sport primary school programme in general. In addition, it can be used to observe how childrens' bodies respond to special and specific training stimuli in relation to changes in body composition, let us say in the distribution of body liquid and changes in muscle mass as well as in connection with the differences of physiological profile. This study is a part of the longitudinal study of young cross-country skiers in the Sport Research Centre, the Faculty of Physical Education and Sport, Charles University in Prague.

Keywords: Body composition, physical performance, children and youth, cross-country skiing, Bioelectric impedance method (BIA), regular training.

INTRODUCTION

Regular training (RT) generally results in a decrease in fatness and an increase in fat free mass (FFM). Hence, RT is an important factor in the regulation of body weight. The increase in FFM observed in youth regularly trained over several years seems to suggest a much greater increase than that expected with normal growth and maturation (Malina & Bouchard, 1991).

RT for sport of young athletes has the potential to influence body composition favorably, by means of increasing the bone mineral and skeletal muscle tissue, and by decreasing fatness (Maffulli et al., 2001). The magnitude of changes in body composition with RT varies with the type, intensity, and duration of the program (Malina & Bouchard, 1991).

Although body composition, as well as its age-related changes, has a strong genetic predisposition, it is also influenced by enviromental factors. The primary influences are nutrition, disease, and physical activity (Bunc et al., 2000b).

At present, the studies of body composition are focusing their attention on changes in body composition during growth, maturation and aging, changes under the influence of physical exercise and sport training, and in addition the connection with obesity and its treatment. Determination of body composition is a common part of the evaluation of dietary habits and the level of physical performance in the athletic population. Greater body fatness can be affected by endurance performance, and the higher values of fat free mass can be an advantage in strength and power activities. Body composition is one of the most important indicators of the development level within ontogenesis, health, fitness, and physical performance, as well as nutrition (Pařízková, 1998).

The body composition of athletic populations is of interest to exercise scientists and clinicians specializing in sports medicine. Generally, a relatively low measure

of body fat is desirable in order to optimize physical performance in sports requiring jumping and running. A large degree of muscle mass enhances performance in strength and power activities. For years, exercise scientists and sports medicine professionals have examined the physiological profiles of elite athletes. Typically, athletes and physically active individuals are leaner than sedentary individuals, regardless of gender. However, female athletes have a relatively greater measure of body fat than male athletes in a given sport, and the average body fatness depends on the type of sport and the athlete's position (Heyward & Stolarczyk, 1996).

Determination of body composition, especially concerning body fat, total body water and according to up-to-date research, even intracellular and extracellular water, and the amount of oxygen processed by muscle cells – the cells which are preferentially performing muscle activity, is an important part of most of the evaluation of so-called health fitness on the one hand, and the assessment of nutrition and an individual's state of health on the other hand (Bouchard et al., 1994; Hannan et al., 1995).

The determination of body composition provides useful information on predisposition for physical performance (Bunc et al., 2000b).

Periodic body composition measurements can be used to assess the effectiveness of exercise (Bouchard et al., 1994) and to monitor changes in body composition associated with the state of growth and maturation of an individual (Bouchard et al., 1994; Heyward & Stolarczyk, 1996), and to classify the level of body fatness in children.

Research shows that fatter children have a stronger tendency to be obese as adults (Heyward & Stolarczyk, 1996).

In the last decade, the use of bioelectric impedance and conductivity methods for the prediction of body composition has grown rapidly. Bioelectric impedance is now regarded as either a substitute or supplement to convential anthropometry in field studies (Roche et al., 1996). The bioelectric impedance method is based on the different properties of tissues, body fat and especially body water (Lukaski et al., 1987). Measuring by the BIA apparatus of the total impedance (by means of variable frequency) can be used to assess not only body fat percentage (fat mass – FM), fat free mass (FFM) and total body water (TBW), but also to assess body cell mass (BCM), which is the sum total of cells able to use oxygen, cells rich in calcium, and cells able to oxidate sugars. Besides BCM, it is possible to determine also extracellular mass (ECM), which is a part of FFM outside the cells, and in addition the value of ratio ECM/BCM. Ratio ECM/BCM is always, in healthy individuals, lower than 1, and the lower this number, the higher the amount of mass which can be used for physical – sport activities (Deurenberg et al., 1995). The above presented factors can be used not only to describe changes in body liquid distribution, but mostly for the purpose of the early interception of changes in the muscle mass structure (Bunc et al., 2000b; Spirduso, 1995).

Body composition is the most important anthropometry indicator in cross-country skiers. The rate of body fat in elite cross-country skiers is 5–10% of the body mass in males and, let us say, 16–22% in females. Male cross-country skiers have as their somatotype the ectomorphic mesomorph, while female skiers are of the endomorphic mesomorph type. Cross-country skiing is a sport discipline which focuses mostly on the pre-season "dry" preparatory training period. Training tools such as running, roller-skiing, cycling, swimming, canoeing, etc. are used for the development of endurance and strength performance. About 20% of the total volume of the training load is the training intensity which is called "the developing intensity". Training should be focused on building up one's musles. Above all, development of upper body muscles is necessary for cross-country skiing, esp. for the requirements of the skating technique (Havlíčková, 1993).

Physical activity, however, is only one of the factors that may influence growth and maturation. An individual's growth and maturation status also influences physical performance. Obviously, growth and maturation status and physical performance are related. The characteristics of the performer affect the physical performance (Malina & Bouchard, 1991).

Adolescence is a key phase in the physical development of children. The processes of maturation and growth which take place during adolescence have profound influence on performance (Maffulli et al., 2001).

In the adult population a dose-response relationship between increased physical activity and the reduction of total adiposity is found (Ross & Janssen, 2001). Knowledge about the same in children and youth is, nevertheless, less clear (Heggebø, 2003).

The aim of this study was to determine body composition parameters and a level of physical performance. The purpose of presented study was also to determine differences in body composition parameters and in the level of physical performance under the influence of regular training performed during the preparatory training period of a group of young cross-country skiers in comparison with non-athletes.

MATERIAL AND METHODS

Observations of body composition and tests of physical performance were performed 2 times (April and October). Second observations were performed after 6 months of the preparatory training period in the skiing season 2003/2004. We have observed a group of

young regularly trained cross-country skiers (CC-skiers), pupils of Sport primary school with a specialization to cross-country skiing (CC-skiing) in Vimperk, and the participants of ski-clubs SKSV (Skiklub Šumava), SOSY (Sokol Stachy) a LIPT (Libín Prachatice) (athletes), in comparison with non-athletes.

By the term non-athletes we understand participants with the similar chronological age like athletes and they take regular physical activity only as a part of their P. E. lessons at school. On the contrary, the athletes trained during the preparatory period four times per week at average and during their training camp two times per day. One training block lasted at least 1 hour. The athletes have passed minimally 1 year of regular training before this testing took place.

The total of 131 participants aged 12 to 15 years (55 girls and 76 boys), out of that 82 CC-skiers (athletes) – 32 girls and 50 boys, and 49 normal controls (non-athletes) – 23 girls and 26 boys, were included in this study.

Anthropometry – body mass (BM) was assessed to the nearest 100 gram on an electronic digital scale. Height was measured to the nearest millimeter using a wall-mounted stadiometer. Body mass index (BMI) was calculated as body mass (kg) divided by squared height (m^2).

Multi-frequency BIA method (B. I. A. 2000M, Data Input, Germany) was used for the determination of body composition in the field conditions.

The level of physical performance was estimated through the basic motor tests including the handgrip by using a dynamometer. The basic motor tests were sit and reach, standing broad jump, bent arm hang, shuttle run 4 × 10 m, five-jump, sit-ups 60 seconds, pull-up 4 metres (climbing).

Values are reported as mean ±SD. For comparison of the groups of non-athletes and athletes, the unpaired two-sample assuming variances t-test was used. For evaluation of changes after observed period (pre-, post-), the paired two-sample for means t-test was used. A p-value < 0.05 was considered statistically significant. We used the predictive equations for boys and girls investigated by Bunc et al. (2000a) to calculate the relative amount of body fat.

RESULTS AND DISCUSSION

The athletes have expressively lower total body mass (BM), lower height and body mass index (BMI), greater percentage of fat free mass (FFM), body cell mass (BCM) (absolute values), and better predispositions to physical performance (the lower value of ratio ECM/BCM) in comparison with non-athletes (TABLE 1).

As it is apparent, the athletes have markedly less relative fatness to non-athletes of the similar chronological age and gender. Thus observed athletes have significantly lower FM (–2.3% – $p < 0.001$) in comparison with non-athletes (TABLE 1).

TABLE 1
Characteristics of the study population – anthropometry and body composition parametres

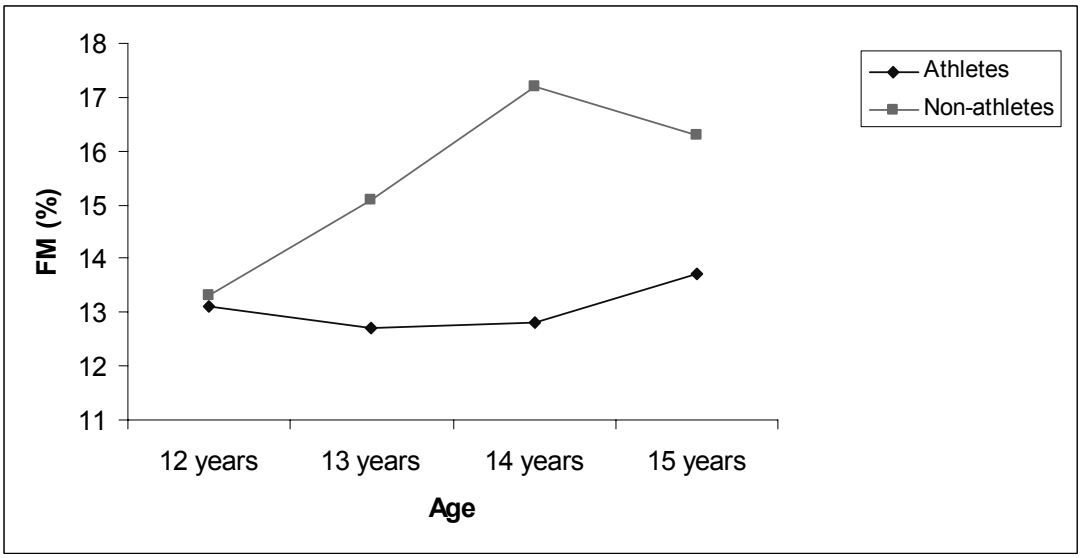
	NON-ATHLETES			ATHLETES		
	In sum	Boys	Girls	In sum	Boys	Girls
	(n = 49)	(n = 26)	(n = 23)	(n = 82)	(n = 50)	(n = 32)
Age (years)	13.6 ± 0.9	13.7 ± 0.9	13.3 ± 0.9	13.4 ± 1.1	13.4 ± 1.1	13.3 ± 1.1
BM (kg)	56.5 ± 12.7	57.5 ± 14.8	55.4 ± 9.7	49.9 ± 11.4 †	50.7 ± 13.4 •	48.6 ± 7.0 †
Height (cm)	163.5 ± 9.5	164.5 ± 11.5	162.3 ± 6.4	161.9 ± 11.0	163.9 ± 12.4	158.6 ± 7.2
BMI ($kg.m^{-2}$)	21.0 ± 3.6	20.9 ± 3.5	21.1 ± 3.7	18.8 ± 2.4 ‡	18.6 ± 2.8 †	19.2 ± 1.8 •
TBW (l)	34.3 ± 7.2	36.8 ± 8.6	31.5 ± 3.5	31.6 ± 6.9 •	32.8 ± 8.2	29.6 ± 3.2 •
FM (%)	16.0 ± 3.9	16.1 ± 3.4	15.8 ± 4.4	13.7 ± 2.4 ‡	14.0 ± 2.4 †	13.3 ± 2.3 ••
FFM (kg)	47.1 ± 8.9	47.9 ± 10.7	46.3 ± 6.2	42.9 ± 8.8 ••	43.4 ± 10.5	42.0 ± 5.2 ••
ECM/BCM	0.95 ± 0.12	0.93 ± 0.13	0.97 ± 0.09	0.94 ± 0.11	0.94 ± 0.12	0.93 ± 0.10
BCM (kg)	24.3 ± 5.9	26.4 ± 7.1	21.9 ± 2.7	22.5 ± 5.6	23.5 ± 6.8	21.1 ± 2.6

Values are reported as mean ±SD.
• $p < 0.05$; •• $p < 0.01$; † $p < 0.005$; ‡ $p < 0.001$ for differences between non-athletes and athletes (in sum, boys and girls) – unpaired two-sample assuming variances t-test; BM = body mass; BMI = body mass index; TBW = total body water; FM = fat mass; FFM = fat free mass; ECM/BCM = ratio of extracellular mass and body cell mass; BCM = body cell mass

The results show age – related increase in FM. The changes of FM with the increasing age are expressively greater in non-athletes, and also the differences of FM in non-athletes to athletes increased with increasing age (except the age of 15) (Fig. 1).

Achieved results confirm formerly founded facts that the fatness increases markedly at the age of 12 (Bunc et al., 2000b), see Fig. 1. This may be caused by increased inactivity related to negative dietary intake in children and youth and it affected by their negative energy balance. At present, this is a typical tendency in population of children and youth.

Fig. 1
Age-related increase in FM – fat mass (%) together with comparison of FM % according to age between athletes and non-athletes



As far as the comparison of anthropometry and body composition parameters between athletes and non-athletes is concerned, that represents both genders, however, there seem to be more marked differences between athletes and non-athletes girls than boys. These results suggest that the regular training (RT), let us say regular physical activity, can be probably more important for girls than boys, and has more potential to influence body composition favorably, by means of increasing FFM, resp. BCM, and by decreasing fatness. Furthermore, it is probably related to the physical fitness levels increasing in girls generally. Athletes girls tend to have especially lower FM (–2.5% – $p < 0.01$), lower ECM/BCM (–0.04), and greater BCM (+2.9%) in comparison with non-athletes girls than boys (TABLE 1).

In addition we can recognize that some of tested athletes have a high level of predisposition to physical performance (ECM/BCM = 0.69) and a low level of FM measured by BIA method and calculated through the predictive equations (e. g. FM = 9.1% in girls, FM = 11.2% in boys).

Gained results show expressive differences in the level of physical performance between athletes and non-athletes. Athletes definitely have an expressively higher level of physical performance as compared to non-athletes in general. That represents both genders. However, athletes girls have much greater level of physical performance than non-athletes girls observed in every motor test, whilst athletes boys have lower performance in sit and reach, handgrip (both hands) and five-jump in comparison with non-athletes boys (TABLE 2). This can be probably caused by the age difference which means that athletes boys are younger by 0.3 years related to expressively lower BM and lower height, thus related to different growth and maturation state in case of handgrip and five-jump. Lower performance in sit and reach in athletes boys may be associated with insufficient stretching exercises used after training load which is probably needed to be supported naturally. The basic motor tests used for the measurement of strength and power (i. e. bent arm hang and climbing 4 metres) are absolutely physically and technically uncontrollable for non-athletes, e. g. almost 29% of the observed non-athletes are not able to pass all 4 metres climbing test.

TABLE 2
Achieved level of physical performance of the study population measured through the basic motor tests

	NON-ATHLETES			ATHLETES		
	In sum	Boys	Girls	In sum	Boys	Girls
	(n = 49)	(n = 26)	(n = 23)	(n = 82)	(n = 50)	(n = 32)
Standing broad jump (cm)	166 ± 32	183 ± 32	148 ± 22	187 ± 20 ‡	190 ± 19	181 ± 18 ‡
Sit-ups 60 seconds (number)	31 ± 9	35 ± 9	28 ± 7	41 ± 8 ‡	41 ± 8 †	41 ± 7 ‡
Shuttle run 4 × 10 m (s)	12.2 ± 1.0	11.8 ± 1.0	12.7 ± 0.9	11.5 ± 0.6 ‡	11.3 ± 0.5 †	11.7 ± 0.6 ‡
Bent arm hang (s)	10.7 ± 12.5	16.0 ± 12.5	4.9 ± 5.0	23.2 ± 13.1 ‡	24.8 ± 13.1 •	21.0 ± 12.4 ‡
Sit and reach (cm)	24.7 ± 6.3	22.5 ± 6.3	27.2 ± 6.0	25.3 ± 7.5	21.4 ± 6.1 •	31.3 ± 5.9
Handgrip (kp) – R	28.0 ± 9.0	31.3 ± 9.0	24.4 ± 4.2	29.0 ± 8.5	30.9 ± 9.7	25.7 ± 4.7
Handgrip (kp) – L	27.7 ± 8.9	31.2 ± 8.9	23.7 ± 3.8	27.9 ± 8.4	30.2 ± 9.4	24.4 ± 4.4
Five-jump (m)	8.7 ± 1.2	9.3 ± 1.2	8.1 ± 0.7	9.4 ± 1.0 ‡	9.7 ± 1.0	9.1 ± 0.8 ‡
Climb 4 m (s)	12.8 ± 10.4	7.6 ± 10.4	19.7 ± 12.6	7.3 ± 3.6 ‡	7.1 ± 3.9	7.6 ± 2.9 ‡

Values are reported as mean ±SD.
• $p < 0.05$; •• $p < 0.01$; † $p < 0.005$; ‡ $p < 0.001$ for differences between non-athletes and athletes (in sum, boys and girls) – unpaired two-sample assuming variances t-test; handgrip – R (right hand); handgrip – L (left hand)

We have found a significant increase of BM by 1.7 kg ($p < 0.001$), height by 1.8 cm ($p < 0.001$), FM by 0.6% ($p < 0.05$), FFM by 1.2 kg ($p < 0.001$), ECM/BCM by 2.1% in athletes (TABLE 3), together with increase of BCM by 1.3%, and significant increase of FFM by 2.8% ($p < 0.001$). Especially, athletes girls have significant increase of FM by 1.2% as well as significant increase of BM by 2.0 kg and significant increase of BMI by 0.4 $kg.m^{-2}$ (TABLE 3), which can be probably associated with the growth and maturation state and natural development.

As far as the changes of body composition in non-athletes are concerned, achieved results show a downgrade of predisposition for physical performance (ECM/BCM = 0.03–3.2%) and a stagnancy or even in girls a decline (see below) of muscle mass increase (BCM = 0.1 kg, 0.4%), together with significant increase of FM by 0.4% ($p < 0.001$). This tendency represents both genders, however, the non-athletes girls tend to have more marked increase of FM by 0.6%, and above all BCM decrease by 0.4 kg than boys (TABLE 3).

Both non-athletes and athletes girls tend to have markedly greater increase of FM than boys. Boys generally tend to have greater increase in BCM (development of muscle mass) (TABLE 3).

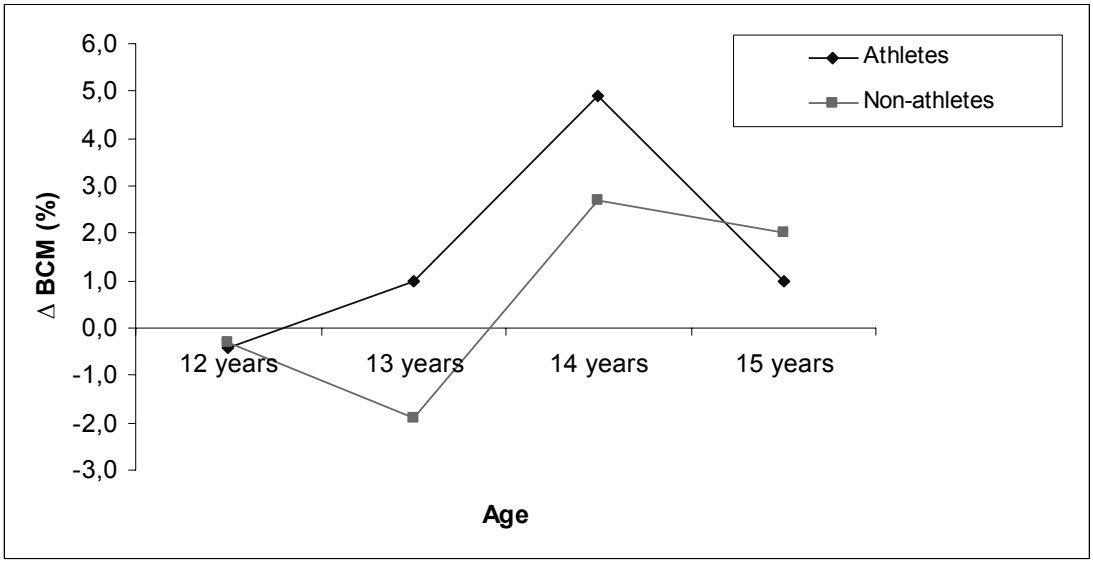
It is important that we have found more favorable changes of BCM in athletes, as compared to non-athletes (TABLE 3 and Fig. 2), which can be associated with a positive effect of RT. Thus, the comparison of body composition between athletes and non-athletes reflects a clear positive influence of performed RT, affecting greater increase in BCM in athletes, especially in girls (TABLE 3). This increase is related to expressively higher level of physical performance (TABLE 2) as well as greater increase of performance in strength and power motor tests in athletes (TABLE 4). Hence, RT can be regarded as a factor helping to sustain a sufficient amount of physical activity required for maintaining or increasing of physical fitness levels, and also as the prevention of overweight or obesity affecting normal development and health of children and youth.

TABLE 3
Differences in anthropometry and body composition parameters achieved after six-month period in followed athletes and non-athletes

	NON-ATHLETES			ATHLETES		
	In sum	Boys	Girls	In sum	Boys	Girls
	(n = 49)	(n = 26)	(n = 23)	(n = 82)	(n = 50)	(n = 32)
BM (kg)	1.7 ‡	2.2 ‡	1.2 †	1.7 ‡	1.5 ‡	2.0 ‡
Height (cm)	1.9 ‡	2.4 ‡	1.3 ‡	1.8 ‡	2.0 ‡	1.5 ‡
BMI ($kg.m^{-2}$)	0.1 ‡	0.2	0.1	0.2	0.1	0.4 ‡
TBW (l)	0.5 •	1.4 •	–0.3	0.7	1.1 •	0.1
FM (%)	0.4 ‡	0.2	0.6 •	0.6 •	0.2	1.2 ‡
FFM (kg)	1.2 ‡	1.6 ‡	0.7 •	1.2 ‡	1.2 ‡	1.1 ‡
ECM/BCM	0.03	0.04	0.02	0.02	0.02	0.02
BCM (kg)	0.1	0.6	–0.4	0.3	0.5	0.1

Values are reported as mean.
• $p < 0.05$; •• $p < 0.01$; † $p < 0.005$; ‡ $p < 0.001$ for evaluation of changes after followed period (pre-, post-) in sum, boys and girls – paired two-sample for means t-test; BM = body mass; BMI = body mass index; TBW = total body water; FM = fat mass; FFM = fat free mass; ECM/BCM = ratio of extracellular mass and body cell mass; BCM = body cell mass; BCM – body cell mass

Fig. 2
Percentage differences in body cell mass (BCM) achieved after six-month period in athletes as compared to non-athletes



As for physical performance differences after the observed period, we have found a significant increase in the level of physical performance in every motor tests except for a decrease of sit-ups and five-jump performance together with stagnancy or increase of climbing in athletes (both genders) (TABLE 4). Achieved results can be probably caused by type, duration and intensity of the performed training load. Athletes have not that significant increase in physical performance (as compared to non-athletes) after the 6 months training period as it was expected. This may be caused by the training load focused more one specialization of specific abilities required for cross-country skiing. Training system was probably focused, above all, on long endurance and other special skills which are necessary to improve physical performance in cross-country skiing. Thus, it was supposedly inadequate to the development of speed, explosibility and probably also facility, which are so

important for the age observed. In addition, it can be associated also with the basic motor tests which have not been able to involve the special training stimuli of cross-country skiing.

The decline of strength performance as well as speed parameters is apparent in non-athletes. That represents both genders, however, non-athletes girls have more markedly negative differences in the level of physical performance after the observed period than boys as compared to athletes (TABLE 4). Non-athletes boys tend to have the same or similar differences, even or greater increase in the level of physical performance determined after the observed period than athletes boys, which can be associated, as presented above, with different age and thus growth and maturation state related to markedly greater increase of BM and height in non-athletes boys (TABLE 3) as well as the effect of special and specific focusing of the training load in athletes boys.

TABLE 4
Differences in the level of physical performance measured through the basic motor tests achieved after six-month period in followed athletes and non-athletes

	NON-ATHLETES			ATHLETES		
	In sum	Boys	Girls	In sum	Boys	Girls
	(n = 49)	(n = 26)	(n = 23)	(n = 82)	(n = 50)	(n = 32)
Standing broad jump (cm)	11 †	15 ••	6	6 ‡	7 †	4
Sit-ups 60 seconds (number)	–2 •	–1	–5 †	–1 •	–1	–2 •
Shuttle run 4 × 10 m (s)	–0.1	–0.1	–0.1	–0.1	–0.2 •	0.0
Bent arm hang (s)	–0.4	–1.3	–0.6	1.2	0.7	1.9
Sit and reach (cm)	1.8 ‡	2.1 †	1.5 •	1.0 ‡	0.6	1.7 ‡
Handgrip (kp) – R	1.5 ••	2.2 ••	0.6	2.1 ‡	2.5 ‡	1.5
Handgrip (kp) – L	2.3 ‡	3.0 ‡	1.5 •	2.1 ‡	2.9 ‡	1.0 •
Five-jump (m)	–0.3 •	–0.2	–0.4 ••	–0.3 ‡	–0.2 †	–0.4
Climb 4 m (s)	3.3 •	–0.1	7.2 •	0.2	–0.1	–0.7

Values are reported as mean.
• $p < 0.05$; •• $p < 0.01$; † $p < 0.005$; ‡ $p < 0.001$ for evaluation of changes after followed period (pre-, post-) in sum, boys and girls – paired two-sample for means t-test; handgrip – R (right hand); handgrip – L (left hand)

The lower percentage of FM in athletes, as compared to non-athletes (especially in girls) (TABLE 1), can be associated with regular training and besides with the type of training load which is generally specialized to endurance in cross-country skiers. The increase of FM observed in youth regularly trained after followed period can be probably associated above all with natural development.

CONCLUSIONS

The regular training was found to favorably improve the body composition by means of decreasing fatness, increasing BCM as well as the greater increase in BCM, related to the level of physical performance.

Results from this study indicate a positive effect of the regular systematic training performed at special (CC-skiing) sport primary school. It concerns firstly the development of young athletes in high performance system, and secondly it is a factor that helps to sustain a sufficient amount of physical activity. We can generalize that it positively influences body composition and physical performance in children and youth. That is a very important today, because as has been often stated, presently there is a tendency to decreased the physical activity levels; consequently the physical fitness levels of school-aged children are falling whilst the obesity levels have in general increased.

According the above presented facts and formerly mentioned findings, regular training can also be used as the prevention of overweight or obesity and thereby affected health and psychical, social and economic complications of youth as well as of adults.

The comparison of body composition between athletes and non-athletes reflects a clear positive influence of performed regular training decreasing relative fatness as well as the greater increasing the amount of BCM and FFM together with greater increase in BCM in athletes. These findings are related to the expressively higher level

of physical performance as well as greater increments in strength performance in athletes, as compared to non-athletes.

The observed age period (especially between the ages of 12 and 13) seems to be generally critical to increasing prevalence of overweight or obesity.

As far as the above presented findings in non-athletes are concerned, significant increase in FM together with indicated trend towards stagnancy or declining of BCM and downgrading of the predispositions to physical performance, are probably caused by the progressive inactivity affecting negative energy balance. The results of body composition and physical performance in non-athletes indicate that it is inevitable to increase a physical activity level, especially in girls.

This study has been made in cooperation with formerly mentioned Sport Research Centre, Faculty of Physical Education and Sport, Charles University in Prague, ZŠ T. G. M. Vimperk, ZŠ Zdíkov, and ski-clubs SKSV, SOSY, LIPT.

The present study is a part of the long-term observation of young cross-country skiers, and it is concerned about their body composition and physical performance, and will be a part of my disertation thesis, which is in preparation.

The results and conclusions can be used for valuable feedback resulting in the improving of training programme in the athletes tested, and to enrich the training system of sport primary schools with a specialization to cross-country skiing, as well as to solve the problems how children and youth bodies respond to specific and special training stimuli concerning body composition and physiological profile. By the way, there still remains the question of to what degree and how it is best to train them.

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VLIV PRAVIDELNÉHO TRÉNINKU NA TĚLESNÉ SLOŽENÍ MLADÝCH LYŽAŘŮ BĚŽCŮ VE VZTAHU K MOTORICKÉ VÝKONNOSTI V POROVNÁNÍ S NORMÁLNÍ POPULACÍ

(Souhrn anglického textu)

Cílem této studie bylo určit tělesné složení a úroveň motorické výkonnosti a zároveň posoudit změny v komponentách tělesného složení a v úrovni motoric-

ké výkonnosti v závislosti na pravidelném tréninkovém zatížení aplikovaném v rámci šestiměsíčního tréninkového programu přípravném období, tzv. „suché přípravy", ročního tréninkového cyklu 2003/2004 u skupiny mladých lyžařů běžců, žáků sportovních tříd při ZŠ T. G. Masaryka ve Vimperku a členů lyžařských oddílů Ski-klub Šumava, Libín Prachatice a Sokol Stachy ve věku 12–15 let (n = 81), v porovnání s normální populací (n = 49). Byla provedena dvě měření tělesného složení a motorické výkonnosti, na začátku a konci přípravného období (duben a říjen), tedy podruhé po šestiměsíčním tréninkovém programu. Metodou pro stanovení tělesného složení byla multifrekvenční bioimpedanční analýza (BIA), zařízení B. I. A. 2000-M, Data Input, Germany měřící celkovou impedanci při použití proměnlivé frekvence. Úroveň motorické výkonnosti byla posuzována na základě výsledků základních motorických testů. Z výsledků vyplývá, že systematický trénink realizovaný v prostředí sportovních tříd má evidentně pozitivní dopad, a to nejen v systému přípravy dětí a mládeže pro vrcholový sport, ale především z hlediska vlivu pravidelného pohybového zatížení aplikovaného nad rámec školních osnov na tělesné složení a motorickou výkonnost dospívajícího organismu. Pravidelný trénink tak může z hlediska tělesného složení působit také jako prevence vzniku nadváhy, případně obezity a s tím souvisejících dalších zdravotních rizik v dospělosti. Výsledky této studie mohou být především hodnotnou zpětnou vazbou vedoucí ke zkvalitnění tréninkové přípravy sledovaných jedinců a k obohacení programu lyžařských sportovních tříd obecně. Stejně tak mohou přispět k řešení problematiky reakce dětského a dospívajícího organismu na speciální a specifickou tréninkovou zátěž z hlediska změn tělesného složení, resp. distribuce tělesných tekutin a změn ve struktuře svalové hmoty, a z hlediska změn fyziologického profilu. Studie je součástí dlouhodobého sledování mladých lyžařů běžců v Laboratoři sportovní motoriky FTVS UK v Praze.

Klíčová slova: tělesné složení, motorická výkonnost, děti a mládež, běh na lyžích, bioimpedanční analýza (BIA), pravidelný trénink.

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Scientific orientation

She is mostly interested in topics concerned with physical development in children and youth, the responses of children and youth to training stimuli, the effects of regular training on body composition, physiological profile, and level of physical performance in young athletes, above all in young cross-country skiers, and additionally in comparison with non-athletes.

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SURFACE EMG AS A METHOD FOR FOLLOWING-UP SPORTS TRAINING EFFICIENCY

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The purpose of the present study was to evaluate the applicability of surface electromyography (EMG) for evaluation of training related changes in muscle contractile properties. Eight nationally ranked junior tennis players participated in a six weeks training program designed to increase speed and explosiveness. Their physical characteristics were evaluated before and after the training period by: tennis-specific field tests, measuring isometric twitch contraction of the medial gastrocnemius muscle, and by monitoring the frequency spectrum of the EMG at 50% of the maximal voluntary contraction. All the players improved the results of tennis specific field tests after the training period, but only three players were recognized to increase contractile speed of the medial gastrocnemius muscle expressed by shorter twitch contraction times after the training period. The same three players exhibited higher characteristic frequency (defined as the mean frequency lying between the sixth and ninth decile of the spectral distribution function) and a wider EMG amplitude spectrum after the training period. A good correlation was found between the number of the parameters of the isometric twitch contraction that were improved by more than 2% after the training period (N_P) and the ratio between characteristic frequency after the training period (f_A) and characteristic frequency before the training period (f_B) (f_A/f_B) ($p = 0.0065$), as well as between N_P and the slope of the linear approximation of the dependence between decile frequencies of the EMG signal after the training period (dAf) and decile frequencies of the EMG signal before the training period (dBf) (dAf = f(dBf)) ($p = 0.0035$).

The correlation between the number of parameters of the isometric twitch contraction that were improved after the training period and the changes in characteristic parameters of EMG suggests the applicability of EMG for following-up sports training efficiency.

Keywords: Twitch contraction, contractile properties, surface EMG, spectral analysis, tennis.

INTRODUCTION

Adolescents' reasons for participation in sports are largely influenced by their psychological state of development. Their feelings about a sport are mostly related to their enjoyment, having fun and affiliation in a group while the extrinsic values such as winning and trophies become a primary motivational factor later in their career (Lee et al., 2000). Trainers spend a significant amount of time with adolescents during training days. They have to ensure that positive benefits arise from children's sporting experience like positive changes in their self-esteem, developing realistic expectations and persisting in physical activity through their later life. On the other hand they are obliged to encourage and promote talent development leading to the highest levels of accomplishment. The evaluation of physical progress due to chosen training methods is indispensably important for talent development, but it is a toilsome task due to adolescents' changeable motivation. Therefore, methods for physical progress evaluation that are independent of motivation are of crucial importance for coaches' work, because only objective information that is promptly translated into practical training methods can assist athletes with both the enhancement of performance and the prevention of injury. Such methods are tests like the pulmonary function and total blood chemistry evaluation, indirect calorimetry, electrocardiographic work-up, body composition assessment and measurements of muscle contraction dynamics. Results provide information on the individual's physical health status and by periodical measurements the coach can critically review the effect of current training protocols.

Muscle contraction dynamics, particularly their contractile properties, are frequently evaluated by measuring whole muscle twitch (Rich & Cafarelli, 2000; Troup et al., 1986; Alway et al., 1989). Muscle twitch contraction characteristics depend on muscle histochemical properties. It has been shown that muscles with a higher percentage of type II fibers show shorter twitch contraction times (Hamada et al., 2000). On the other hand the relationships between proportions of muscle fiber types and areas and frequency content of EMG have been observed (Kupa et al., 1995; Seki & Narusawa, 1998; Gerdle et al., 2000; Larsson et al., 2001).

In the unfatigued state, positive correlations between the proportion of type II muscle fibers and the mean frequency of the power spectrum have been reported for the gastrocnemius, vastus lateralis and trapezius muscles (Gerdle et al., 2000). Many studies have indicated that specific training induces changes in twitch contraction characteristics (Rich & Cafarelli, 2000; Alway et al., 1989; Harridge et al., 1998) and authors have also reported that specific training induces changes in the surface EMG parameters (Rich & Cafarelli, 2000). Consequently we have anticipated that a relationship exists between training induced changes in twitch contraction characteristic and changes in surface EMG parameters in the frequency domain.

In this work we focused on tennis, a game which demands from an athlete a sustained high level of technical, tactical, psychological and physiological ability due to its complexity, speed, dynamic nature and the long duration of the match. Tennis play requires a high level of physical fitness related to such factors as strength, power, muscular endurance, flexibility, coordination and agility (Roetert & Ellenbecker, 1998). Both upper and lower body power are necessary. Upper body strength is needed to achieve efficient strokes. On the other hand lower body strength is required for sprinting to the ball, changing directions, stretching, stopping and starting, and balance (Roetert et al., 1996). After all, muscular endurance is important owing to the long duration of the match. Roetert et al. (1992) reported that in young male tennis players agility and speed have a higher correlation to tennis performance than is the case for any other physical performance factor. Players with explosive first steps get into position quickly, set up well, and hit effective shots (Roetert & Ellenbecker, 1998). In addition, an explosive first step gives players the speed necessary to get to the ball, when it has been hit far away (Roetert et al., 1995). Owing to the complexity of tennis, a measuring technique that could give the coach proper estimation of the player's physical progress in view of speed and explosiveness would be a great benefit. It should be independent of the observer, the player's knowledge of the test, footwear, weather and psychological factors such as motivation.

The main purpose of the present study was to evaluate the applicability of surface electromyography (EMG) as a non-invasive and pain-free technique for the evaluation of training related changes in muscle contractile properties. Thus, a group of junior tennis players went through a six week period of an intensive training program designed to increase speed, agility and explosiveness. Players' physical progress due to the training program was evaluated in three ways: (1) classically, by tennis-specific field tests, (2) by measuring isometric twitch contraction of the medial gastrocnemius muscle, and (3) by monitoring the frequency spectrum of the surface EMG at 50% of the maximal voluntary contraction. Our hypothesis was that training would increase the contractile speed of the medial gastrocnemius muscle, which could be observed through the changes in twitch contraction characteristics. In the next step of the study, the correlation between the changes in twitch contraction characteristics and changes in surface EMG parameters in frequency domain was tested.

METHODS

Eight nationally ranked junior tennis players (mean (max/min) age: 12.7 (15/12) years) participated in the study. The players and their parents were informed about the experimental procedure as well as familiarized with the possible risks and discomfort before they gave their written consent. The tennis players performed a set of tennis-specific field tests and were subjected to a set of biomechanical measurements before the six week period of the intensive training program. After this period, the set of tennis-specific field tests and biomechanical measurements were repeated. Measurement protocols are described below.

Tennis-specific field tests:

Six tennis-specific field tests were chosen. Three of them (hexagon, spider run and sideways shuffle) are well known and described elsewhere (Roetert & Ellenbecker, 1998). As the fourth test the number of skips over a skipping rope in 30 s was selected and the task was named "skipping rope". The fifth test was denoted "3 × 30 s". The player started at the center of the service court. At the mark he/she ran to the singles sideline, touched the line with a racket, ran to the center service line, touched the line with his/her racket and so forth for 30 s. The task was repeated three times with two breaks of 30 s and the number of all touches was noted down. The last test was a "groundstroke shuffle". Two points were marked on the tennis court, both 3 m from the baseline and 1 m from each singles sideline. The player started at the center of the baseline. At the mark he/she ran to the left point, simulated one of the ground strokes (forehand or backhand) there, returned to the baseline, ran to the right point, simulated one of the ground strokes again, returned to the baseline, etc. The number of strokes in 30 s was scored.

Biomechanical measurements and electromyography:

The medial gastrocnemius muscle was selected for biomechanical measurements because it is one of the leg muscles that has to accommodate to explosive movement patterns and is highly involved in the push-off action of the forehand drive, backhand drive and volley (Roetert & Ellenbecker, 1998). During the meas-

urements the subject was seated in a comfortable chair with the knee flexed at a 90 degree angle. The ankle joint was aligned with the axis of rotation of the ankle joint torque meter consisting of a strain-gauge transducer that transformed the torque into voltage. Then the foot and shank were firmly fixed.

Twitch contraction:

Muscle dynamics was measured through isometric twitch contraction. An isometric twitch contraction was elicited by stimulating the medial head of the gastrocnemius muscle with a single, square wave stimulus of 0.5 ms duration and supramaximal intensity. The skin was slightly abraded and cleansed with ethyl alcohol. Bipolar, self-adhesive surface electrodes (Pals Platinum electrodes, Axelgaard Manufacturing Co., Ltd.) were placed on the skin, one on the motor point and the other near the tendon. We used a GRASS S88 stimulator (Grass Product Group, Astro-Med, Inc., West Warwick, USA), with voltage output, in conjunction with an insulation unit (SIU5 RF Transformer Isolation Unit, Grass Product Group, Astro-Med, Inc., West Warwick, USA). The measured muscle responses were stored to a computer and analyzed using Matlab 5.3 Software (Math Works, Inc., Natick, USA).

Five parameters were chosen for characterization of the isometric twitch contraction: T_{lat}: the latency period, i. e., the time between the stimulus and the beginning of the contraction; T_{50}: the time to half-tension, i. e., the time between the beginning of the contraction and 50% of the peak tension; T_{peak}: the time to peak tension, i. e., the time between the beginning of the contraction and the peak tension; T_{half}: the half relaxation time, i. e., the time between the peak tension and the half-tension of relaxation phase; α: inclination, i. e., the inclination of the torque curve at 50% of the peak tension.

Electromyography:

The subject was given verbal instructions in the performance of a maximal voluntary isometric contraction (MVC) of the medial gastrocnemius. The subject was then asked to perform the MVC for five seconds as a reference contraction, and the maximal voltage was marked. This maximal voltage served as the 100% MVC for the normalization procedure. The subject was then instructed to flex the ankle joint again and to maintain 50% of the previously determined maximum voluntary isometric contraction for 15 seconds. In the meantime (between the 5th and 10th second of contraction) one second of the surface EMG signal was sampled at 5 kHz and stored to a computer. EMG was measured and amplified (gain 100) by means of the commercially available Myolab II Model ML 200 system (Motion Control Inc., Salt Lake City, USA). Electrodes were placed on the muscles of the belly between the innervation zone and the tendon in a direction parallel to the muscle fibers and fixed with elastic straps with Velcro attachments that were tightened just enough to hold the electrodes in place without obstructing blood flow. The position of the electrode was marked on the skin by a non-toxic ink pen to ensure the same electrode location in both measurements. The subjects were requested to maintain markings between sessions. The recorded EMG data were processed off-line using Matlab 5.3. We assumed that EMG signal was stationary during the measuring episode (Marletti & Lo Conte, 1995).

First, we filtered EMG data via the fifth-order Butterworth bandpass filter with the cut-off frequencies 10 and 500 Hz to eliminate frequency content of non-physiological origin (Clancy et al., 2002). A fast Fourier transformed (FFT) algorithm was performed to calculate its spectral characteristics. The spectral distribution function, defined as the normalized integral of the amplitude spectrum (i. e. the magnitude of the Fourier transform), was calculated (Lowery et al., 2000; Lowery et al., 2002). The location of each decile frequency was determined from this curve; for example, the sixth decile corresponds to the frequency below which occupies 60% of the area of the spectrum (Marletti & Lo Conte, 1997). The mean frequency between the sixth and ninth decile was defined as a characteristic frequency. This definition of characteristic frequency is based on the spectral distribution technique proposed by Lowery et al. (2000), who reported the mean shift in the midfrequency region (between the sixth and ninth deciles) of the EMG amplitude spectrum as a more accurate indicator of muscle fiber conduction velocity changes than the mean or the median frequency of either the power or amplitude spectrum.

RESULTS

Six players performed at least four tennis-specific field tests (from among six) before and after the six weeks training period. The results of all six tennis-specific field tests are shown in Fig. 1. The players as a group improved the results in the hexagon (paired t-test, $p = 0.001$), groundstroke shuffle (paired t-test, $p = 0.005$) and skipping rope (paired t-test, $p = 0.02$) tests. As can be seen from Figure 1, the players mostly improved also the results in the other three tests (spider run, sideways schuffle and 3×30 s), but the improvement of the whole group was not statistically significant. Three players (i. e., 2, 4 and 7) participated in all (i. e., six) tennis-specific field tests before and after the training period. After the training period, player 2 attained better results in all the six tennis-specific field tests, while the players 4 and 7 did not attain better results in one of the tests. Players 3 and 8 participated in the

five tennis-specific field tests before and after the training period. After the training period player 8 attained better results in all the five tennis-specific field tests, while player 3 improved the results of four tests. Player 6 participated in the four tennis-specific field tests before and after the training period and did not improve the results in one of the four tests. According to the chosen set of tennis-specific field tests all the players that participate in both testing periods enhanced their tennis performances after six weeks of special training since they attained better results in more than half of the tennis-specific field tests after the training period. Moreover they statistically significantly improved the results of a half tennis-specific field tests as a group.

The six weeks training period resulted in changes in isometric twitch parameters. If the parameters T_{lat}, T_{50}, T_{peak} and T_{half} were shortened by more than 2%, and the parameter α was increased by more than 2%, we assumed that the parameters were improved. One player (player 6) improved all five parameters of the isometric twitch contraction, and two players (player 2 and player 5) improved four. Five players improved just two (player 4 and player 8), one (players 1 and 3) or none (player 7) parameters. Only three players (i. e., 2, 5 and 6) improved more than half of the parameters of isometric twitch contraction and were therefore recognized to increase the contractile speed of the muscle after six weeks of special training.

After six weeks of special training the characteristic frequency of the medial gastrocnemius muscle increased in players 2, 5 and 6, decreased in players 4, 7 and 8, and pettily decreased in players 1 and 3. It is interesting to note that before the beginning of the training, players 2, 5 and 6 had statistically significant lower (Student's t-test; $P = 0.025$) characteristic frequencies than the rest of the players. Good correlation between the number of the parameters of the isometric twitch contraction that were improved more than 2% in the second measuring period (N_P) and the ratio between characteristic frequencies after (f_A) and before (f_B) the training period (f_A/f_B) were found ($r^2 = 0.7357$, $p = 0.0065$). This result is presented in Fig. 2a. Fig. 3 depicts decile frequencies of the EMG signal after the training period (dAf) as a function of decile frequencies of the EMG signal before the training period (dBf) for each player. The amplitude spectrum of the EMG signal did not change during the training period in players 1 and 3, thus the function dAf = f (dBf) is a straight line with the slopes 0.97 and 0.98 respectively. Also in the cases of players 2 and 5 the functions dAf = f (dBf) are almost straight lines with a slope greater then 1 (1.14 and 1.12 respectively), i. e., the EMG amplitude spectrum after the training period was widened uniformly. The curve dAf = f (dBf) of player 6 is not a straight line and its inclination is greater then 1, i. e., the EMG amplitude spectrum after the training period was wider and had a different shape then the EMG amplitude spectrum before the training period. In the players 4, 7 and 8 the EMG amplitude spectrum after the training period is compressed with regard to the EMG amplitude spectrum before the training period; i. e., the inclinations of the curves dAf = f (dBf) are under one. For the players 4 and 8 the curves are almost straight lines with slopes of 0.86 and 0.85 respectively, while the curve dAf = f (dBf) of the player 7 differs from a straight line. As can be seen from Figure 2B, a good correlation was found between the number of parameters of the isometric twitch contraction that were improved in the second measuring period (N_P) and the slope of the linear approximation of the function dAf = f (dBf) ($r^2 = 0.7831$, $p = 0.0035$). Again, the players 2, 5 and 6 were recognized as having increased the speed of the medial gastrocnemius muscle after six weeks of special training, since the EMG amplitude spectrum after the training period was wider.

DISCUSSION

All the players that participated in both testing periods improved the results of tennis specific field tests after six weeks of special training. However biomechanical measurements showed that the contractile properties of the medial gastrocnemius muscle were not equally changed in all players. Measurements of muscle twitch response showed that only three players (i. e., 2, 5 and 6) increased the muscle contraction velocity expressed by shorter isometric twitch contraction parameters T_{lat}, T_{50}, T_{peak} and T_{half} and increased α. After six weeks of special training the same three players exhibited also a higher characteristic frequency and wider amplitude spectrum of the EMG signal measured at 50% of the maximal voluntary contraction. Several authors reported that the type of muscle fibers influenced both the frequency content of EMG signals and the muscle contraction velocity. In general, higher values of the median or mean power frequency of the EMG power spectrum are observed for muscles with a greater proportion or relative area of type II fibers (Kupa et al., 1995; Gerdle et al., 2000; Bilodeau et al., 2003). Muscles with a higher content or larger area of type II fibers are also associated with shorter twitch contraction times that express the higher contraction velocity of these muscles (Hamada et al., 2000; Buchthal & Schmalbruch, 1970; Rice et al., 1988). Therefore, according to the literature and the results of the study we can conclude that medial gastrocnemius muscle fibers of the players 2, 5 and 6 adapted to special physical training. The adaptation resulted in an increase in the area (hypertrophy) or even in the content (hyperplasia) of type II fibers. The results of biomechanical measurements are in context

with coaches' observations and the opinion that players 2, 5 and 6 have high self-esteem, are highly motivated, competitive and value hard work. Each and all of them have also strong support from their parents.

We get a high correlation between the number of the parameters of the isometric twitch contraction that were improved in the second measuring period (N_P) and the slope of the function dAf = f (dBf) obtained from EMG measurements ($r^2 = 0.7831$, n = 8, p = 0.0035) as well as between N_P and the ratio between the characteristic frequencies f_A and f_B (f_A/f_B) ($r^2 = 0.7357$, n = 8, p = 0.0065). These relationships support the suggestions (Cifrek et al., 2000) that surface EMG as an objective, completely non-invasive and pain-free technique might be applicable as method for following-up sports training efficiency.

Fig. 1
The results of tennis-specific field tests

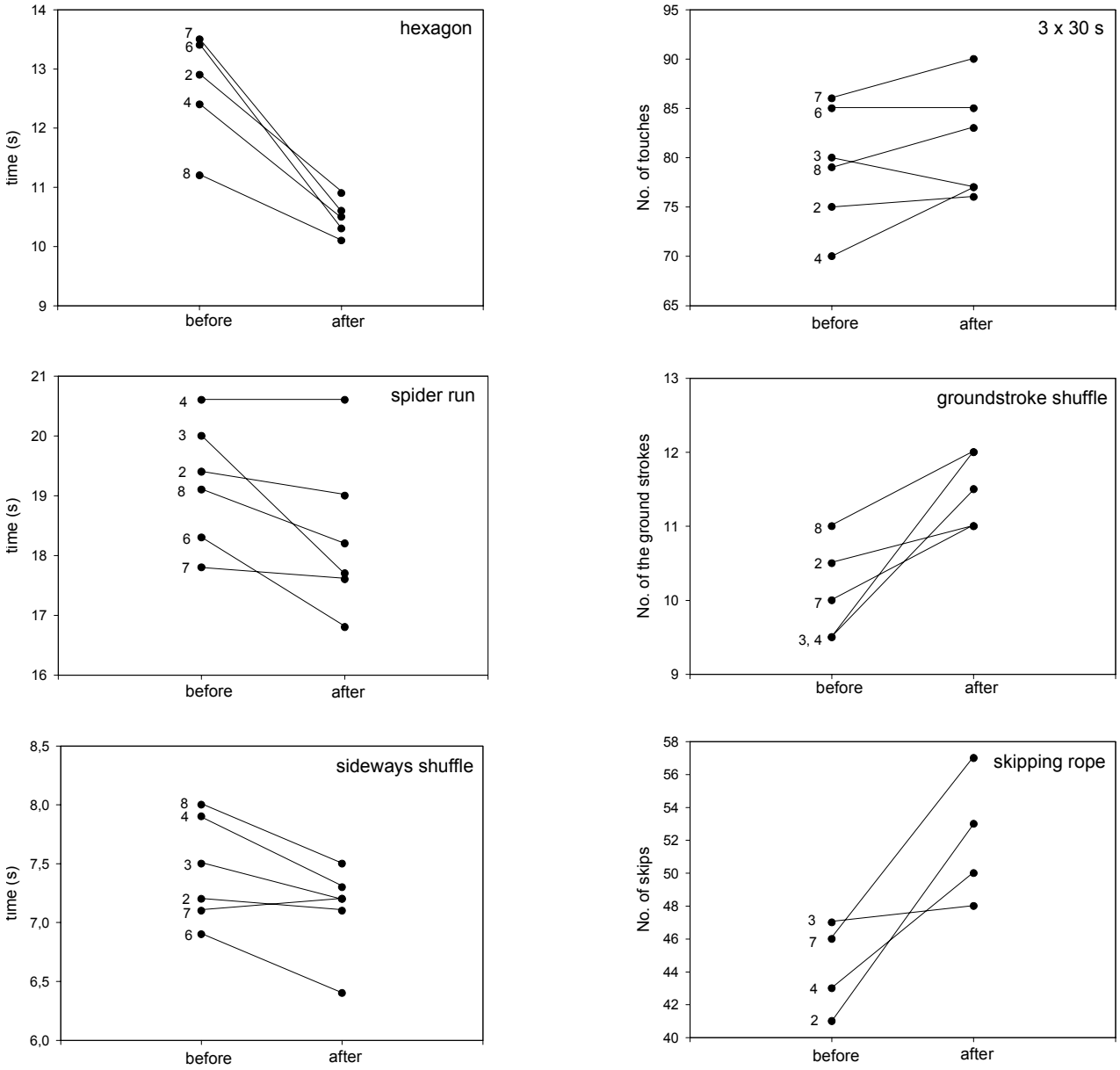


Fig. 2
Correlation between two biomechanical methods:
A) Correlation between the number of the parameters of the isometric twitch contraction that were improved by more than 2% in the second measuring period (N_P) and the ratio between characteristic frequencies f_A and f_B (f_A/f_B)
B) Correlation between the number of parameters of the isometric twitch contraction that were improved in the second measuring period (N_P) and the slope of the linear approximation of the function dAf = f (dBf)

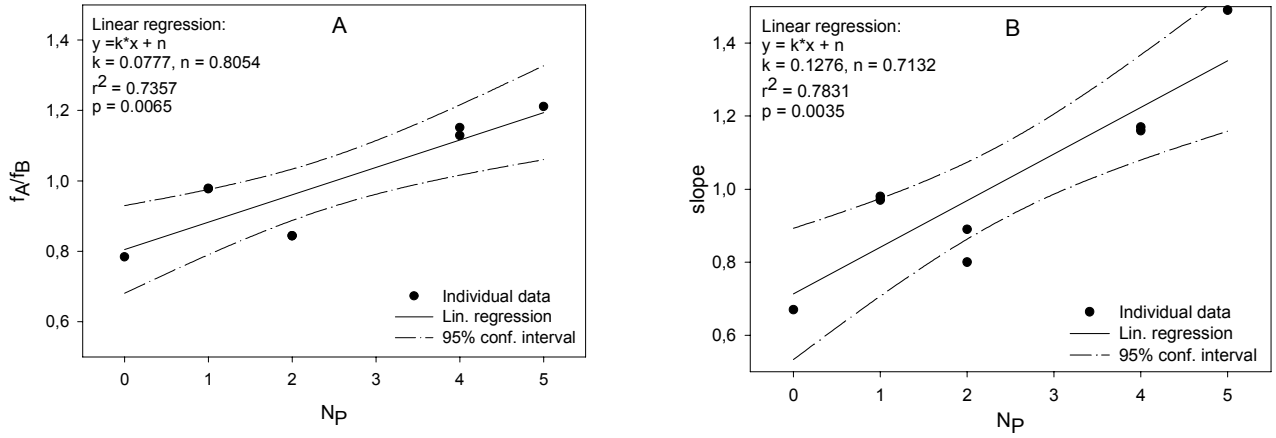
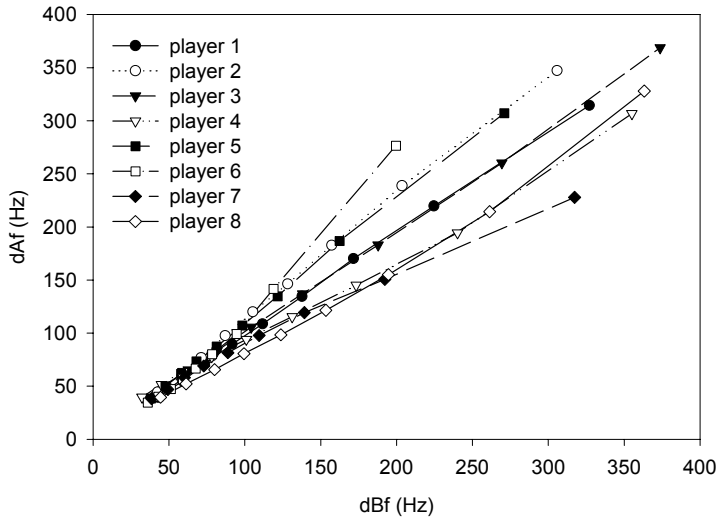


Fig. 3
Decile frequencies of the EMG signal after the training period (dAf) as a function of decile frequencies of the EMG signal before the training period (dBf) for each player



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EMG (ELEKTROMYOGRAFIE) JAKO METODA PRO SLEDOVÁNÍ ÚČINNOSTI SPORTOVNÍHO TRÉNINKU

(Souhrn anglického textu)

Účel této studie byl zhodnotit vhodnost a použitelnost povrchové elektromyografie pro vyhodnocení změn kontrakčních vlastností svalů spojených s tréninkem.

Skupina osmi národních juniorských tenistů se zúčastnila šestitýdenního výcvikového programu, který byl zaměřen na zvýšení rychlosti a výbušnosti. Jejich fyzické charakteristiky byly zhodnoceny před a po období programu, a to specifickými tenisovými testy, které měří izometrickou kontrakci trhnutí středního gastroknemického svalu, a zaznamenáváním spektra frekvence EMG při 50% maximální volní kontrakci.

Ve specifických tenisových testech se prokázalo, že většina hráčů zlepšila své výkony po výcvikovém období, pouze u 3 hráčů byla zjištěna zvýšená rychlost kontrakce středního gastroknemického svalu, která byla vyjádřena kratší dobou kontrakčního trhnutí po období výcviku. Stejní hráči předvedli vyšší charakteristickou frekvenci (definována jako střední frekvence ležící mezi 6. a 9. decilem spektrální distribuční funkce) a širší EMG spektrum rozkmitu po výcvikovém období. Vysoká korelace byla zjištěna mezi počtem parametrů

izometrické kontrakce trhnutí, která byla zlepšena o více než 2 % po období výcviku (Np), poměr mezi charakteristickou frekvencí po období výcviku (f_A) a před výcvikovým obdobím (f_B) (f_A/f_B) (p = 0,0065), a také mezi N_p a stoupáním lineárního přiblížení závislosti mezi decilovými frekvencemi signálů EMG po období výcviku (dAf) a před výcvikovým obdobím (dBf) (dAf = f(dBf) (p = 0,0035).

Korelace mezi počtem parametrů izometrické kontrakce trhnutí, které byly zlepšeny po období výcviku, a změny v charakteristických parametrech EMG evokují použitelnost EMG pro sledování účinnosti sportovního výcviku.

Klíčová slova: kontrakce trhnutí, kontrakční vlastnosti, povrchová EMG, spektrální analýza, tenis.

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ANALYSIS OF STRUCTURE OF THE BIATHLON RUNS

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The biathlon is an Olympic sport discipline, which is a combination of two events, Nordic skiing and precision shooting. Combining events of such different psychophysical background creates great demands on the athlete and coach. The main objective of this paper was to determine which of these events has a greater impact on the final result considering the distance and sports level. The results of the World Cup and the Olympic Games in the 2001/02 season were analyzed statistically. The data indicates that the results of the run influence the final result to a higher degree than shooting does. This is especially true in the sprint and in relation to biathletes of higher sports level. At long distances, the level of shooting and the time of the run influence the final result to the same extent. The influence of the time of shooting on the final result is dependent on the distance of the run.

Keywords: Biathlon, analysis of sport results.

INTRODUCTION

The biathlon is an Olympic sport discipline, which is a combination of Nordic skiing and precision shooting. Combining such different physical efforts is very difficult, thus making this sport discipline very attractive to television and live viewers, especially in Europe.

During biathlon competition the athletes cover a distance of 6 to 20 km which is interrupted by shooting, which occurs 2 to 4 times depending on the event. Shooting takes place from a distance of 50 m and each time the athlete takes 5 shots to an electronic or mechanical target composed of 5 black circles. If the target is hit the black circle closes automatically.

There are two shooting positions in the biathlon, standing and lying down. The order of these positions depends on the event. Penalties for missed shots include an additional minute added to the final time in the individual run or an additional 150 m round performed immediately after the shooting in all other events. During competition the athletes choose the shooting spots themselves (except for the first shooting in competitions with a greater number of participants as well as in relays). The athletes control the performance of penalties themselves.

The biathlon includes several events: individual run, sprint, pursuit run, mass run, and relays. In this work, data from individual runs and sprints was analyzed. In the individual run men cover a distance of 20 km (5 × 4 km), while women compete at 15 km (5 × 3 km) with 4 shooting sessions in the lying and standing positions in this order: lying, standing, lying, standing. As mentioned earlier, each missed shoot is penalized by an addition of 1 min to the final time. The sprint is performed at shorter distances, 10 km for men and 7.5 for women respectively. Shooting takes place only twice in the sprint, beginning with the lying position and followed by the standing one. Each miss is penalized by an additional run over a distance of 150 m, performed immediately after the shooting. The penalty run usually takes 22 to 25 s. The start of successive competitors begins at 30 s intervals.

Factors influencing shooting results:

The biathlonist shoots under completely different conditions than athletes specializing in this event. The biathlonist shoots for precision but performs this task within a limited time. The biathlonist approaches shooting under a certain level of fatigue caused by previous running. The shooting occurs at an elevated heart rate, with increased ventilation and increased stimulation of the CNS (Klusiewicz, 2000).

The biathlete faces drastic changes in weather conditions: temperatures, wind, sun, fog, and snow. The biathlete also has to adjust to the conditions of shooting related to the position and to the limited time for performing the shooting tasks (Hoffman et al., 1992).

The final result is also affected by the types of targets used – mechanical or electronic as well as the mechanical efficacy of the gun, especially optical devices (Wasilewski, 1977).

Factors effecting running time:

The time of the run includes the time the biathlete spends on the course without the time spent for shooting. Many factors affect running time in the biathlon

of which the most important include weather conditions which directly influence the quality of snow and configuration of the course (amount of hills and their difficulty level). The quality of skiing equipment also affects running time (Ewstratow et al., 1989). The most important factor influencing running time includes the level of physical fitness as well as technical and tactical preparation.

Because of the complexity of tasks in the biathlon, achieving a world class level by a talented athlete requires 8–12 years of systematical training, aimed at developing a high level of physical and psychomotor fitness as well as great skiing and shooting skills (Ewstratow et al., 1989; Krasicki et al., 1995; Łarionow, 2002; Ryguła, 2002; Rundel & Szmere, 1998). It is evident that creating proper external conditions allows for the development of the internal potential of a particular athlete, which guarantees the achievement of world class results (Kłodecka-Różalska, 2002; Raczek, 1986; Rundell & Bacharach, 1995).

The final result is an outcome of two main elements: the time of the run and the shooting score. Skiing requires a high level of aerobic endurance, while shooting demands precision and mental control. From a scientific point of view it is important to determine which of these elements has a decisive effect on the sport result. Answering such a question will allow for more effective planning of the training program.

It is evident that other factors such as: weather conditions, type of course and snow as well as the quality of equipment influence the result in the biathlon (Ewstratow, 1989; Krasicki, 1999; Nunar et al., 1998), yet they were omitted from this research report.

AIM AND RESEARCH QUESTIONS

The main objective of the paper was to determine the influence of shooting results and running time on the final result in the biathlon.

The following research questions were formed.

1. What is the relationship between the running time, shooting efficiency, quickness of shooting and the end result in particular events of the biathlon?
2. How do particular components of the biathlon change depending on the distance and sports level?

MATERIAL AND METHODS

The data included results of the World Cup and Olympic Games during the 2001/2002 season. The number of subjects varied from 67 to 110 in particular events. The athletes represented 35 nations. The average age of the athletes was 28.4 ± 8.5 years while the training experience equaled 12.8 ± 6.3 years. Career analysis indicated that 29% of the considered athletes began as Nordic skiers while 71% specialized in the biathlon from the beginning.

All of the information related to the athletes was obtained from the JBU Biathlon Calendar 2001/2002, which included basic data of national representatives.

The results were analyzed statistically. For this purpose precise information from official bulletins of individual runs from the 2001/2002 season were used. World Cup runs from Osbrlie, Pokljuka, Antholz-Anterselva and the Olympic run from Salt Lake City were analyzed. Also sprint runs from Ostersund, Ruhpolding, Osbrlie and the Salt Lake City were considered. Athletes who performed occasionally in World Cup events were excluded from the analyses, especially in view of the fact that their results were 30% worse than those of the elite biathlonists. The smallest number of athletes considered included 67 at Ostersund, while the most were analyzed in Ruhpolding during the World Cup. The analysis was conducted for all the athletes as well as for the top 30 in each run.

All of the collected data was analyzed statistically with the use of a PC program called "Statistica". The results were presented as means ($\bar{x}$), variance (V), standard deviation (SD) and extreme results (E). In order to determine the relationships between particular components of the biathlon run (time, shooting efficiency) and the final result, Pearson's correlation coefficients were calculated. The level of significance was set at $p < 0,05$.

RESULTS AND DISCUSSION

The obtained results are presented in TABLE 1–6 and Fig. 1–4.

The analysis of the correlation coefficients (TABLE 5, 6) indicates a great variability of results. The highest relationship between the final result of the biathlon and particular elements of the run was observed for the sprint. The value of the coefficients between the time of the run and the final result ranged from 0.78 to 0.90. The relationship between shooting efficiency and the final result ranged from 0.50 to 0.70. In those cases where the time of the run had the highest influence on the end result, the relationship between shooting efficiency had the lowest values of coefficients, which may be related to very even competition and only two shooting sessions.

In the individual run, the running time has the greatest influence on the final result (r = 0.80–0.86). Shooting efficiency has a much greater impact on the final result (r = 0.67–0.77), which is most likely related to

more frequent shooting during the competition (the possibility of committing more mistakes).

The final results as well as the times of the run and shooting results of all athletes and the top 30 show great variation. The similarity of results is very high for the top 30 athletes as confirmed by small values of SD and variation. Excellent shooting, understood as 0 penalties or 1 penalty, guarantees a place in the top 30 if the time of the run is close to the average result. The dispersion of the time of the 20 km run of the top 30 athletes equaled: 5.32; 5.43; 5.53; 6.55 (TABLE 2). These are high differences yet those athletes placed high.

The elite biathletes possess a very similar level of shooting, which is obtained when the amount of misses are close to the average (3.5 to 4.5 missed shots) in the long distance runs.

Shooting efficiency, analyzed on the basis of the top 30 athletes reduces the range of penalties from 1.7 to 2.4 for each 20 shots (approximately 90% efficiency), where as the worst shooting biathlete got 4 penalties during the Olympic Games and 5–6 penalties at the World Cup. This does not indicate directly that the biathlete who received 5 penalties reached a lower position.

During the sprint runs the average amount of missed shots equals from 1.7 to 2.3 with the worst result reaching 6–8 penalties. Such shooting eliminates the possibility of obtaining a good final result. The top 30 biathletes in the sprint runs reached an average of 0.9–1.5 missed shots (90%) efficiency with the worse result equal to 5 penalties.

The research also included the influence of shooting time on the final results. This time is measured from the moment the athlete takes the shooting spot until the last shot. It includes body alignment and the motor tasks necessary for performing 5 shots. The relationships of this time with the final result are dependent on the distance covered and time of the run. Shooting time is of greater importance in the sprint in comparison to long distance competitions. The worse the final time the higher the influence of shooting time on the final result. A higher sports level in the biathlon is accompanied by a smaller influence of the shooting time on the final result because of small differences in this variable in elite athletes. The differences in shooting time among top biathletes is insignificant.

In comparison of correlation coefficients among all analyzed variables among all competitors and the top 30 biathletes, smaller values of these coefficients were observed among the elite athletes. Small standard deviations in all variables in the elite biathletes indicate a very even level of physical, technical and mental preparation among them. It can be suggested that other factors not considered in this work may influence the final result among elite biathletes.

A review of the literature shows little data regarding the analysis of the structure of the biathlon. The obtained results are consistent with those presented by other authors. In analyzing the final results of the men's 20 km biathlon, Pustovrh et al. (1995) stated that there were great differences in the influence of particular components of the run depending on the sports level of the competitors. He considered the top 10 and last athletes of the World Championships. Among the top biathletes, all of the components had a similar influence on the final result, while in the athletes with poor final results, the time of the run was crucial.

Rundell et al. (1995) demonstrated a high relationship between the final result and the time of the run, which was dependent to a large degree on the VO_{2max} of the athlete.

Groslambert et al. (1997) considered the influence of other factors on the final result in the biathlon, yet they came to the conclusion that maintaing high running velocity before shooting was the dominant factor.

CONCLUSION

1. Depending on the sports level, the influence of shooting efficiency and the time of the run is varied. Among the elite biathletes the influence of the time of the run on the final result is smaller than in athletes of lower sports level.
2. Because of the great similarity of results in shooting among the top biathletes the decisive factor includes running velocity. The highest correlation between the time of the run and the final result occurs in the sprint.
3. Shooting efficiency has a significant influence on the end result during individual competition, where shooting occurs 4 times and the possibility of committing mistakes is greater.
4. The influence of shooting time on the final result is dependent on the distance and time of the run. The lower the value of the final time (individual run, sprint) the greater the influence of shooting time.

TABLE 1
The statistical analysis of the final time and the time of the run

Time and place of competition	n	Min	Max	$\bar{x}$	V	S	Min	Max	$\bar{x}$	V	S
		Final time					**Time of the run**				
Individual											
Osbrlie PŚ	106	0:54:08	1:08:41	1:00:45	17'33''	3'58''	0:51:56	1:00:41	0:55:53	14'18''	2'34''
Pokljuka PŚ	100	1:00:02	1:16:46	1:06:23	16'42''	3'51''	0:56:32	1:13:41	1:02:25	17'09''	2'51''
Antholz PŚ	91	1:04:58	1:20:20	1:10:57	15'22''	3'44''	1:00:14	1:15:01	1:07:48	14'42''	2'47''
Salt Lake City IO	84	0:51:03	1:05:58	0:57:08	14'55''	3'05''	0:49:03	0:58:58	0:53:43	9'55''	2'07''
Sprint											
Ostersund PŚ	67	0:26:39	0:33:04	0:28:48	6'25''	1'15''	0:24:06	0:28:07	0:25:48	4'01''	0'50''
Ruhpolding PŚ	110	0:24:05	0:29:19	0:26:32	5'14''	1'18''	0:20:44	0:24:58	0:23:30	4'14''	0'58''
Osbrlie PŚ	106	0:28:18	0:31:15	0:31:15	7'55''	1'45''	–	–	–	–	–
Salt Lake City IO	84	0:24:51	0:27:31	0:27:31	6'42''	1'21''	0:22:59	0:26:46	0:24:39	3'47''	0'52''

$\bar{x}$ – means
V – variance
S – standard deviation

TABLE 2
The statistical analysis of the final time and the time of the run among 30 top biathletes

Time and place of competition	n	Min	Max	$\bar{x}$	V	S	Min	Max	$\bar{x}$	V	S
		Final time					**Time of the run**				
Individual											
Osbrlie PŚ	30	0:54:08	0:58:02	0:56:28	3'54''	0'66''	0:51:56	0:57:51	0:54:04	5'43''	1'18''
Pokljuka PŚ	30	1:00:02	1:04:11	1:00:09	6'09''	1'17''	0:56:32	1:02:25	0:59:59	5'53''	1'10''
Antholz PŚ	30	1:04:58	1:08:39	1:07:15	3'41''	0'58''	1:00:19	0:07:14	1:04:46	6'55''	1'35''
Salt Lake City IO	30	0:51:03	0:55:35	0:53:52	4'32''	1'20''	0:49:03	0:54:35	0:52:07	5'32''	1'20''
Sprint											
Ostersund PŚ	30	0:26:39	0:28:34	0:27:44	1'55''	0'31''	0:24:06	0:26:20	0:25:12	2'14''	0'29''
Ruhpolding PŚ	30	0:24:05	0:25:35	0:25:03	1'30''	0'21''	0:20:44	0:22:32	0:21:33	1'48''	0'24''
Osbrlie PŚ	30	0:28:18	0:30:06	0:29:33	1'18''	0'26''	–	–	–	–	–
Salt Lake City IO	30	0:24:51	0:26:50	0:26:15	1'19''	0'29''	0:22:59	0:24:38	0:23:51	1'39''	0'26''

TABLE 3
The statistical analysis of shooting time and penalties

Time and place of competition	n	Min	Max	$\bar{x}$	S	Min	Max	$\bar{x}$	S	1 missed shot expressed in % of the best final time
		Quickness of shooting				**Shooting efficiency**				
Individual										
Osrblie PŚ	106	1'49''	4'03''	2'18''	0'26''	0	11	4.5	2.3	1.8%
Pokljuka PŚ	100	–	–	–	–	0	11	4.1	2.2	1.6%
Antholz PŚ	91	1'45''	3'05''	2'18''	0'16''	0	9	3.9	1.8	1.6%
Salt Lake City IO	84	1'41''	3'16''	2'11''	0'15''	0	7	3.3	1.7	2.0%
Sprint										
Ostersund PŚ	67	0'44''	1'44''	1'00''	0'09''	0	8	2.2	1.6	1.4%
Ruhpolding PŚ	110	0'47'	1'58''	1'05''	0'11''	0	6	1.9	1.3	1.5%
Osrblie PŚ	106	–	–	–	–	0	6	2.3	1.5	1.3%
Salt Lake City IO	84	0'48''	2'02''	1'06''	0'11''	0	6	1.7	1.1	1.6%

TABLE 4
The statistical analysis of shooting time and penalties among the 30 top biathletes

Time and place of competition	n	Min	Max	$\bar{x}$	S	Min	Max	$\bar{x}$	S	1 missed shot expressed in % of the best final time
		Quickness of shooting				**Shooting efficiency**				
Individual										
Osrblie PŚ	30	1'49''	3'29''	2'13''	0'19''	0	5	2.4	1.2	1.8%
Pokljuka PŚ	30	–	–	–	–	0	6	2.4	1.4	1.6%
Antholz PŚ	30	1'45''	2'35''	2'03''	0'12''	0	5	2.4	1.3	1.6%
Salt Lake City IO	30	1'41''	2'27''	2'04''	0'11''	0	4	1.7	1.0	2.0%
Sprint										
Ostersund PŚ	30	0'44''	1'16''	0'56''	0'07''	0	4	1.3	1.0	1.4%
Ruhpolding PŚ	30	0'47'	1'18''	0'58''	0'08''	0	3	0.9	0.9	1.5%
Osrblie PŚ	30	–	–	–	–	0	5	1.5	1.1	1.3%
Salt Lake City IO	30	0'48''	1'21''	1'00''	0'07''	0	2	1.1	0.7	1.6%

TABLE 5
Correlation coefficient for the considered variables

	Individual				Sprint			
Time and place of competition	Osrblie PŚ	Pokljuka PŚ	Antholz PŚ	Salt Lake City IO	Ostersund PŚ	Ruhpol-ding PŚ	Osrblie PŚ	Salt Lake City IO
(n)	106	100	91	84	67	110	106	84
Relationship between final result and time of the run	0.80	0.82	0.86	0.85	0.78	0.87	–	0.90
Relationship between the final result and shooting efficiency	0.77	0.67	0.71	0.77	0.70	0.51	0.61	0.57
Relationship between the final result and quickness of shooting	0.47	–	0.25	0.49	0.50	0.52	–	0.52

TABLE 6
Correlation coefficient for the considered variables among the top 30 biathletes

	Individual				Sprint			
Time and place of competition	Osrblie PŚ	Pokljuka PŚ	Antholz PŚ	Salt Lake City IO	Ostersund PŚ	Ruhpol-ding PŚ	Osrblie PŚ	Salt Lake City IO
(n)	106	100	91	84	67	110	106	84
Relationship between final result and time of the run	0.47	0.33	0.50	0.71	0.58	0.55	–	0.82
Relationship between the final result and shooting efficiency	0.38	0.61	0.14	0.38	0.35	0.31	0.47	0.27
Relationship between the final result and quickness of shooting	0.14	–	0.21	0.19	0.47	0.16	–	0.26

Fig. 1
Correlation coefficient for the considered variables in the individual run

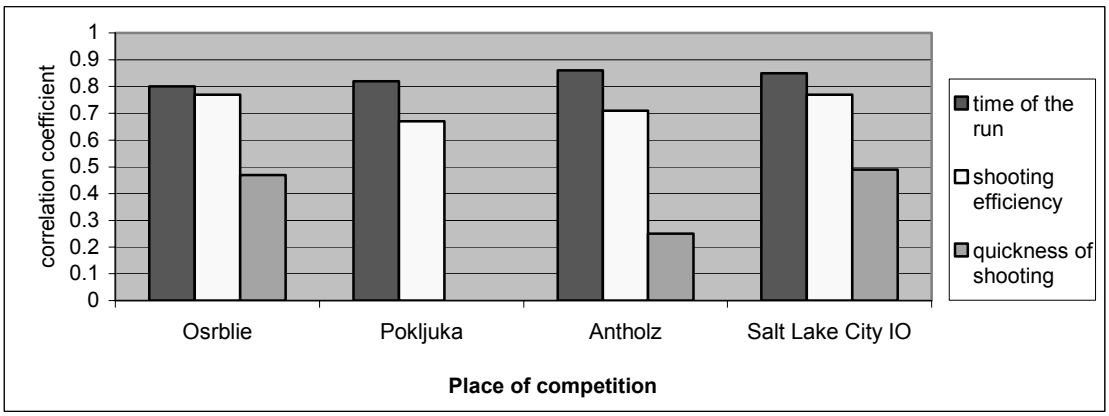


Fig. 2
Correlation coefficient for the considered variables in the sprint

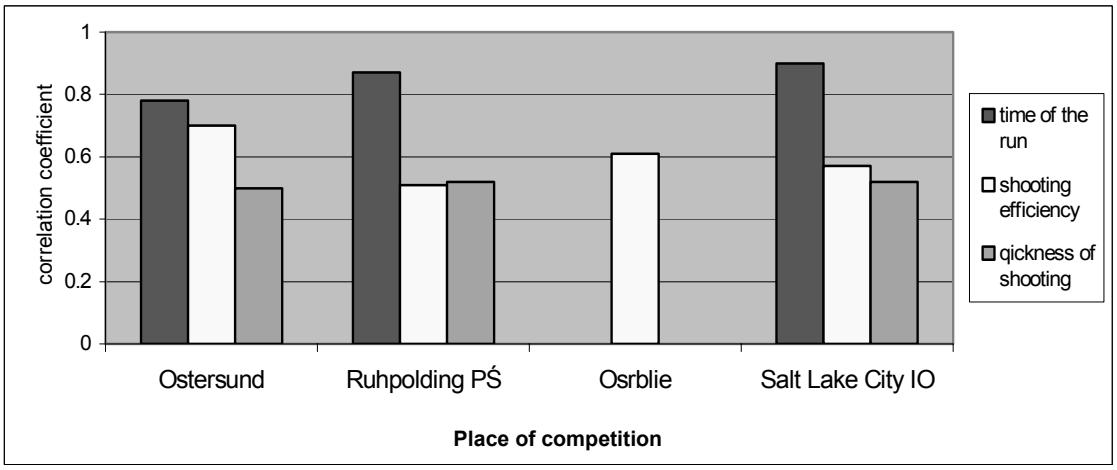


Fig. 3
Correlation coefficient for the considered variables in the individual run, among the top 30 biathletes

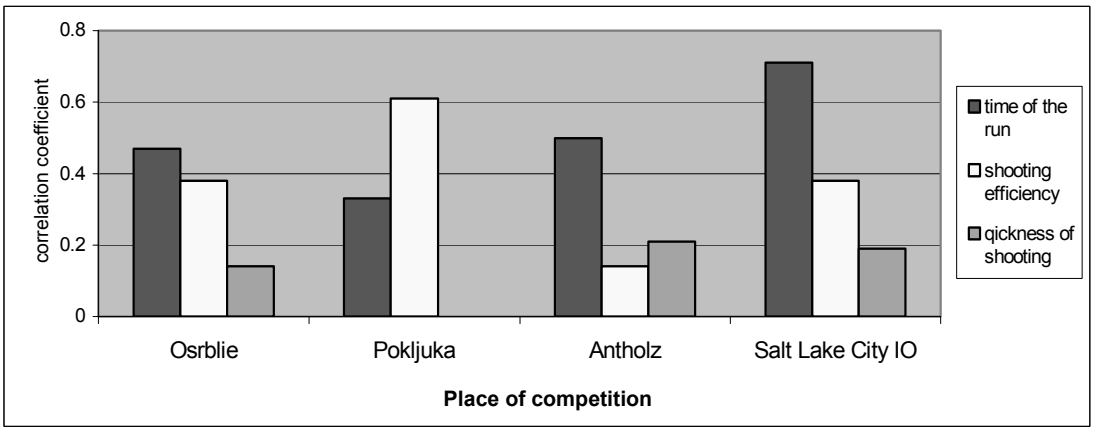
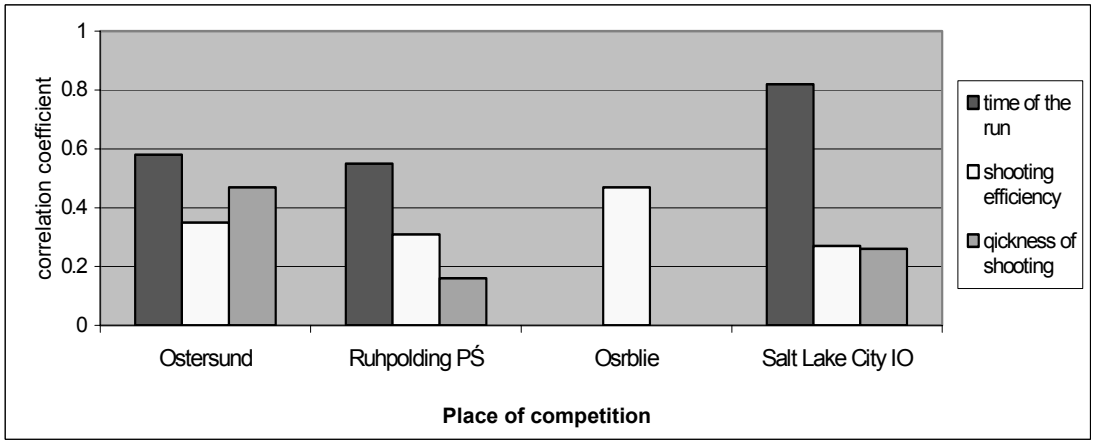


Fig. 4
Correlation coefficients for the considered variables in the sprint, among the top 30



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ANALÝZA STRUKTURY BIATHLONOVÉHO BĚHU

(Souhrn anglického textu)

Biathlon je olympijská disciplína spojující v sobě vlastně dvě sportovní disciplíny: lyžařský běh a střelbu ze sportovní pušky. Spojení těchto odlišných sportovních disciplín o různých psychofyzických požadavcích klade na závodníky i trenéry velmi vysoké požadavky. V práci se autoři snažili najít odpověď na otázku: která složka je důležitější pro dosažení konečného výsledku v závislosti na proběhnuté vzdálenosti, jakož i sportovní úrovni závodníků. Statistické analýze byly podrobeny výsledky vybraných závodů Světového poháru i olym-

pijských her v sezóně 2001/02 v kategorii mužů. Analýze byl podroben čas běhu, přesnost střelby, čas střílení i sportovní výsledek. Na základě výsledků získaných z předmětné analýzy byl zjištěn větší význam běhové přípravy v sprintérském běhu u závodníků na vyšší sportovní úrovni vzhledem k vysoké vyrovnané úrovni střelby. V běhu na dlouhých tratích byl zjištěn přibližně stejný význam přesnosti střelby a času běhu. Vliv času střelby na konečný výsledek závisí na délce proběhnuté vzdálenosti.

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THE EFFECT OF INTERVENTIONAL PHYSICAL ACTIVITY OF RESIDENTIAL CAMPS IN NATURE ON THE HABITUAL PHYSICAL ACTIVITY OF FEMALES AND MALES

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The main aim of this study is to ascertain the effect of physical activity (hereafter PA) of residential camps in nature on habitual weekly PA and to compare the level of performed PA to health epidemiological recommendations. The effect of females' (n = 49) and males' (n = 27) PA at residential camps (the experiential camp GO! in Hynčice pod Sušinou, the residential camp in Lipnice nad Sázavou and the school in nature in Volyně) was assessed by comparing it to their habitual weekly PA, performed at a three-week interval after the end of these camps. PA was monitored using the accelerometer Caltrac, the pedometer Omron and individual records. PA was assessed by active energy expenditure (Caltrac), number of steps (Omron) and time of PA (individual record). At every analysed residential camp in nature, the volume of PA meets the epidemiological recommendations for strengthening health. The content and form of PA at residential camps in nature also erases differences between females' and males' PA and weekend and working days. PA performed at the school in nature in Volyně and at the residential camp in Lipnice provided a strong impulse for the development of fitness in males and females. We showed the strong effect of "interventional" PA on habitual weekly PA in both females ($r_P = 0.55$) and males ($r_P = 0.60$) at the school in nature in Volyně and a moderate effect on females ($r_P = 0.39$) at the experiential camp GO!.

Keywords: Active energy expenditure, steps, workday, weekend, Caltrac accelerometer, Omron pedometer.

INTRODUCTION

Characterization of basic paradigms used in this study:

- **Physical activity** – denotes any body movement produced by skeletal muscles and leading to an increase of energy expenditure of the individual (Carpensen, Powell, & Christenson, 1985, 126) "...a complex behavior which generally accounts for 15 to 40% of a person's total energy expenditure" (Bouchard, Shephard, & Stephens, 1994, 9).
- **Active energy expenditure** – is "a consumption of energy sources which is necessary to cover physical activity (without basal metabolism)" (Frömel, Novosad, & Svozil, 1999, 131). It includes the FITT characteristics (frequency, intensity, type and time) of performed PA. In field conditions we use the accelerometer Caltrac to assess active energy expenditure.
- **Health** – "...is an impermanent state of physical, mental and social peace and not only absence of diseases and health defects" (Sharkey, 1990, 4). We lean towards accepting the holistic view of health as a system of "physical", "mental", "social" and "spiritual" health, where any impairment of one single item results in disruption of the whole system. We also understand health as an individual value, which includes the ability to decide the content of free time.

The most relevant epidemiological recommendations on performing PA in relation to health refer to a week (Biddle, Sallis, & Cavill, 1998; Pangrazi, Corbin, & Welk, 1996; U.S. Department of Health and Human Services, 2000). A week's monitoring and backward recording of PA is a current trend of the objective ascertaining of the level of PA of children, youth and adults (Craig et al., 2003; Trost et al., 2002; Washburn, Jacobsen, Sonko, Hill, & Donnelly, 2003) and, also due to this, it allows comparison between working days and weekend days (Trost, Pate, Freedson, Sallis, & Taylor, 2000). Epidemiological recommendations as to optimal PA in relation to health (Biddle, Sallis, & Cavill, 1998; Pangrazi, Corbin, & Welk, 1996; U.S. Department of Health and Human Services, 2000) are most frequently expressed with frequency and intensity of performing PA:

- Children and youth – PA of moderate intensity for 30–60 minutes daily – Corbin, Pangrazi and Welk (1994), which includes continuous PA at least for 3 days per week for 20 minutes per occasion – Pangrazi, Corbin, and Welk (1996),
- Children and youth – PA of moderate intensity at least for 5 or more days per week for 3 minutes per

occasion. Increase the proportion of adolescents who engage in vigorous PA that promotes cardiorespiratory fitness 3 or more days per week for 20 or more minutes per occasion (U.S. Department of Health and Human Services, 2000),
- Adults – increase the proportion of adults who engage regularly, preferably daily, in moderate PA for at least 30 minutes per day. Increase the proportion of adults who engage in vigorous PA that promotes the development and maintenance of cardiorespiratory fitness 3 or more days per week for 20 or more minutes per occasion (U.S. Department of Health and Human Services, 2000).

But there are also recommendations expressed with active energy expenditure:
- Children and youth – 6 to 8 kcal·kg^{-1}·day^{-1} – Corbin, Pangrazi, and Welk (1994)
- Adults – 90 kcal·kg^{-1}·week^{-1} – Cordian, Gotshall, Eaton and Eaton, III (1998)
- All – "...that an increase of about 150 kcals per day, or 1.000 kcals per week, over sedentary levels, was sufficient to improve health. Vigorous activity was not required for these effects" (Sallis & Owen, 1999).

Besides active energy expenditure from Caltrac, for assessing PA in relation to health and fitness we also take into consideration the number of steps measured by the pedometer Omron, the time of PA and the ratio of active to total energy expenditure. Frömel, Novosad and Svozil (1999) set forth three values (listed below) in order to have basic orientation in assessing the PA of children and youth. Those values respect social, cultural, mental and educational aspects.
- Active energy expenditure should reach at least 9 kcal·kg^{-1}·day^{-1} in girls (resp. 11 kcal·kg^{-1}·day^{-1} in boys) for a majority of week days.
- The daily number of steps should approach 11.000 in girls of basic school age (resp. 13.000 in boys) for a majority of week days.
- The daily number of steps shoud approach 9.000 in girls of secondary school age (resp. 11.000 in boys) for a majority of week days.

Worldwide, weekend days including more free time are paradoxically more critical from the point of view of PA of children and youth than working days (Gavarry, Giacomoni, Bernard, Seymat, & Falgairette, 2003; Hovell, Sallis, Kolody, & McKenzie, 1999). Although boys are physically more active than girls on school days (Gavarry et al., 2003), on weekend days the differences in volume and content of PA between boys and girls get reduced due to the increase in physical inactivity (Gavarry et al., 2003).

Weekend days, with plenty of free time, provide an appropriate occasion for physical intervention. Okada et al. (2000) confirmed that regular vigorous PA performed only once per week, just at the weekend, markedly decreased the risk of diabetes mellitus type 2 in men (n = 6013) aged 35–60.

Advanced western countries support interventional projects aimed at the increase of daily PA of inhabitants, right eating habits and active lifestyle. The reason is the reality that physical inactivity, with its wide range of health consequences, represents a major avoidable contribution to the costs of illness in the United States and other countries with modern lifestyles that have replaced physical labor with sedentary occupations and motorized transportation (Colditz, 1999). In addition to changes in eating habits and behaviour (Armstrong, Sallis, Hovell, & Hofstetter, 1993; Epstein, Saelens, & O'Brien, 1995; Saelens et al., 2000), health supporting projects are primarily aimed at increase of PA and restriction of physical inactivity (J. K. Ockene, McBride, Sallis, Bonollo, & I. S. Ockene, 1997; Okada et al., 2000; Owens et al., 1999). Multidisciplinary interventional programs, which embrace an increase in PA, dietetical recommendations, motivation for active lifestyle and improvement of knowledge of PA and health, are rated as the most effective interventional programs (Dishman & Buckworth, 1996; Sallis et al., 2000; Simons-Morton, Calfas, Oldenburg, & Burton, 1998).

AIM

The purpose of this study is to find out the effect of physical activity performed at residential camps in nature on habitual weekly PA and to compare the level of performed PA to health recommendations.

METHODS

Characterization of residential camps in nature and monitored participants:

School in nature in Volyně – "interventional" camp designed for pupils of basic school in Chomutov. Morning classes last 3 to 4 hours. The afternoon program was designed to include active spending of free time by PA, while passive relaxation (e. g. reading books, listening to music, watching TV) was not excluded. The school in nature in Volyně offers a well-equipped sports field (sports grounds for football, basketball, volleyball, tennis, baseball, badminton, softtennis, table tennis, balls for all kinds of games, skipping ropes, rackets, darts, and the like) and possibility of hiking and bike trips into surrounding nature. There were 14 girls at the age of 15.17 (M) ± 0.61 (SD) and 12 boys at the age of

15.09 (M) ± 0.31who took part in the monitoring. Monitoring of "interventional" and habitual PA took place from the 28th of March to the 4th of April 2000 and from the 25th of April to the 1st of May 2000.

Experiential camp GO! in Hynčice pod Sušinou (Margagata 2001) – the aim of the camp was a meeting of participants (pupils) and their class teacher and to create informal relationships and social relations in the newly formed class "team". The camp was drawn up as a voyage (margagata in Sanskrit) from the land of the "basic school" to the land of "Gymnazion" (secondary grammar school) where the participants would be supposed to spend the next part of their life. Opening of the camp represented boarding a sailboat "Margagata" and setting sail towards "Gymnazion". The camp took place from the 2nd of August to the 8th of August 2001. Habitual PA was monitored from the 29th of August to the 5th of September 2001. There were 18 females (at the age of 15.39 ± 0.27 years) and 5 males (at the age of 15.45 ± 0.87 years) who participated in this monitoring of PA.

Residential camp in Lipnice nad Sázavou (Polis Lipnae) – as the main goal of this camp students of recreology (FTK UP Olomouc) got acquainted with methods and possibilities of "experience pedagogy". This camp was composed as an example of a camp of this type. The stay at the camp was brought into line with the life in polis of ancient Greece – "Polis Lipnae". 17 females (at the age of 20.15 ± 1.62 years) and 10 males (at the age of 20.83 ± 1.62 years) participated in the monitoring of PA at the camp from the 16th of June to the 22nd of June and habitual PA from the 13th of July to the19th of July 2001.

Monitoring of PA

Monitoring is based on the triangulation approach to the measurement of PA by the accelerometer Caltrac (active energy expenditure), the pedometer Omron (number of steps) and the individual record (time of duration, type and frequency of PA and physical inactivity), (Frömel, Novosad, & Svozil, 1999). For precise monitoring of PA it is recommended to use a combination of various approaches and methods, such as accelerometers and questionnaires, multifunctional motion sensors, direct observation and accelerometers or pedometers, questionaires and heart rate sensors (Baranowski & de Moor, 2000; Basset, 2000; Lamonte & Ainsworth, 2001).

In field conditions, accelerometers are suitable devices for the monitoring of the physical behaviour of a midsized group of children and youth (Janz, Witt, & Mahoney, 1995; Ott, Pate, Trost, Ward, & Saunders, 2000), particularly for several days', week's or even longer monitoring (Freedson & Miller, 2000; Janz, Witt, & Mahoney, 1995; Trost, Pate, Freedson, Sallis, & Taylor, 2000; Welk, Corbin, & Dale, 2000).

For assessment of active energy expenditure in field conditions, the accelerometer Caltrac was validated by comparison with a heart rate sensor (Montoye, Kemper, Saris, & Washburn, 1996) which was also done by a week's monitoring of Czech adolescents (Frömel, Novosad, & Svozil, 1999). Active energy expenditure from Caltrac significantly correlates with the number of steps from the pedometer Omron ($r_P = 0.62$, $p < 0.0000$) and time of duration of PA from the individual record ($r_P = 0.48$, $p < 0.0000$) by all-day field monitoring of PA of 190 boys and girls at the age of 11–12 (Sigmund, 2000).

According to individual data (weight, height, age and sex; length of step and weight respectively), the accelerometer Caltrac (the pedometer Omron respectively) were set up for measuring active energy expenditure in kilocalories or number of steps.

Every proband was intimately instructed how to "wear" the accelerometer Caltrac and the pedometer Omron and how to write down data about PA into the individual record sheet. An elastic belt strongly and exactly fixed the devices over the right hip during the all-day monitoring, except for sleeping, lying in bed, personal hygiene and swimming. Every morning and evening probands put down times, active energy expenditure and steps during PA into their record sheet. Before going to bed they also put down types, times of duration and intensity of PA. The number of wrong or incomplete individual records was lower than 5 %, thanks to schooled students of the Faculty of Physical Culture Palacký University, who supervised the rightness of monitoring at outdoor camps as well as during monitoring of habitual weekly PA. For comparison of PA at residential camps in nature and habitual weekly PA we select only those probands who had completed both monitoring issues.

Statistical processing

The effect of PA performed at residential camps in nature on habitual weekly PA was assessed by r_P – Pearson's correlation coefficient of relative variable – active energy expenditure ($kcal \cdot kg^{-1} \cdot day^{-1}$). Dishman and Buckworth's (1996) classification of r_P: small ($r_P = 0.10$), moderate ($r_P = 0.30$) and large ($r_P = 0.50$) effect. The coefficient of determination (r_P^2) expresses the percentual effect of PA at residential camps in nature on habitual weekly PA of monitored females and males.

RESULTS

The volume of PA at each of the monitored residential camps in nature fulfils epidemiological recommen-

dations for stengthening health (Fig. 1, 2). Although all camps were not primarily aimed at progress of fitness, PA at school in nature in Volyně and at the residential camp in Lipnice nad Sázavou even provides conditions for fitness progression in both females and males.

The highest effect of "interventional" PA on habitual weekly PA was registered at the school in nature. Active energy expenditure ($kcal \cdot kg^{-1} \cdot day^{-1}$) at the school in nature in Volyně influenced the active energy expenditure in the habitual week by 36 % or 30 % in males or females. The school in nature in Volyně was, above the other camps, most aimed at performing PA and fitness.

Habitual weekly PA, monitored during a habitual week in girls who took part in the experiential camp GO!, was influenced by 15% by the PA performed at the experiential camp GO! in Hynčice pod Sušinou, we consider it a moderate effect of "interventional" PA. Only a few males (n = 5) took part in the experiential camp GO! and successive monitoring of habitual weekly PA, therefore we will not speculate on the effect of "interventional" PA.

While previous cases deal with assessment of the effect of "interventional" PA on habitual PA in a habitual week, the case of the residential camp in Lipnice nad Sázavou is different. Students of recreology at FTK UP form a highly selective group and monitoring of habitual weekly PA took place in the period of the summer holidays, when we found considerable variance in active energy expenditure, number of steps and time of duration of PA. In this case we are not able to speak about the effect of PA at the residential camp in Lipnice nad Sázavou on habitual PA (females $r_P = 0.09$, males $r_P = 0.06$).

DISCUSSION

Environment is a strong motivation factor for PA. The environment of the school in nature in Volyně is furnished with sports fields (sports grounds for football, basketball, volleyball, tennis, baseball, badminton, soft-tennis) and sport equipment (tables for ping-pong, balls for all kinds of games, skipping ropes, rackets, darts, and the like). To make use of the glamorous nature environment is a priority of the residential camp in Lipnice nad Sázavou and the experiential camp GO! in Hynčice pod Sušinou.

Females and males of all camps positively evaluated and took advantage of the possibility of deciding on their free time PA. Even in their habitual daily schedule participants placed emphasis on the possibility of arranging their free time themselves. Free time spent in this way is mostly evaluated as better used than time organized by someone else. In the case of pupils of the school in nature in Volyně, it is in harmony with the level of their mental development, which is manifested by criticalness and nonobjectivity.

Content was a common positively evaluated character of all three camps. More than 75% of the respondents, without any significant differences between females and males, emphasize compounded content – well-known and uncustomary movement and sports games, the possibility of their individual or team realization and the atmosphere of friendship, which dominated over the spirit of "competition" and "comparison". More than ⅔ of participants declared that an experiential camp is a strong motivation impulse for the further performance of PA – above all after-school PA.

An informal interview showed that 79% of females and 84% of males at the school in nature in Volyně are first of all interested in sports and PA. This finding is confirmed by the first-rank popularity of PE lessons. Watching TV was the second most often performed activity, but pupils' interest in sports was more than two times higher. Other popular activities are: spending time with friends, working with the computer, music and minimally reading or fine arts.

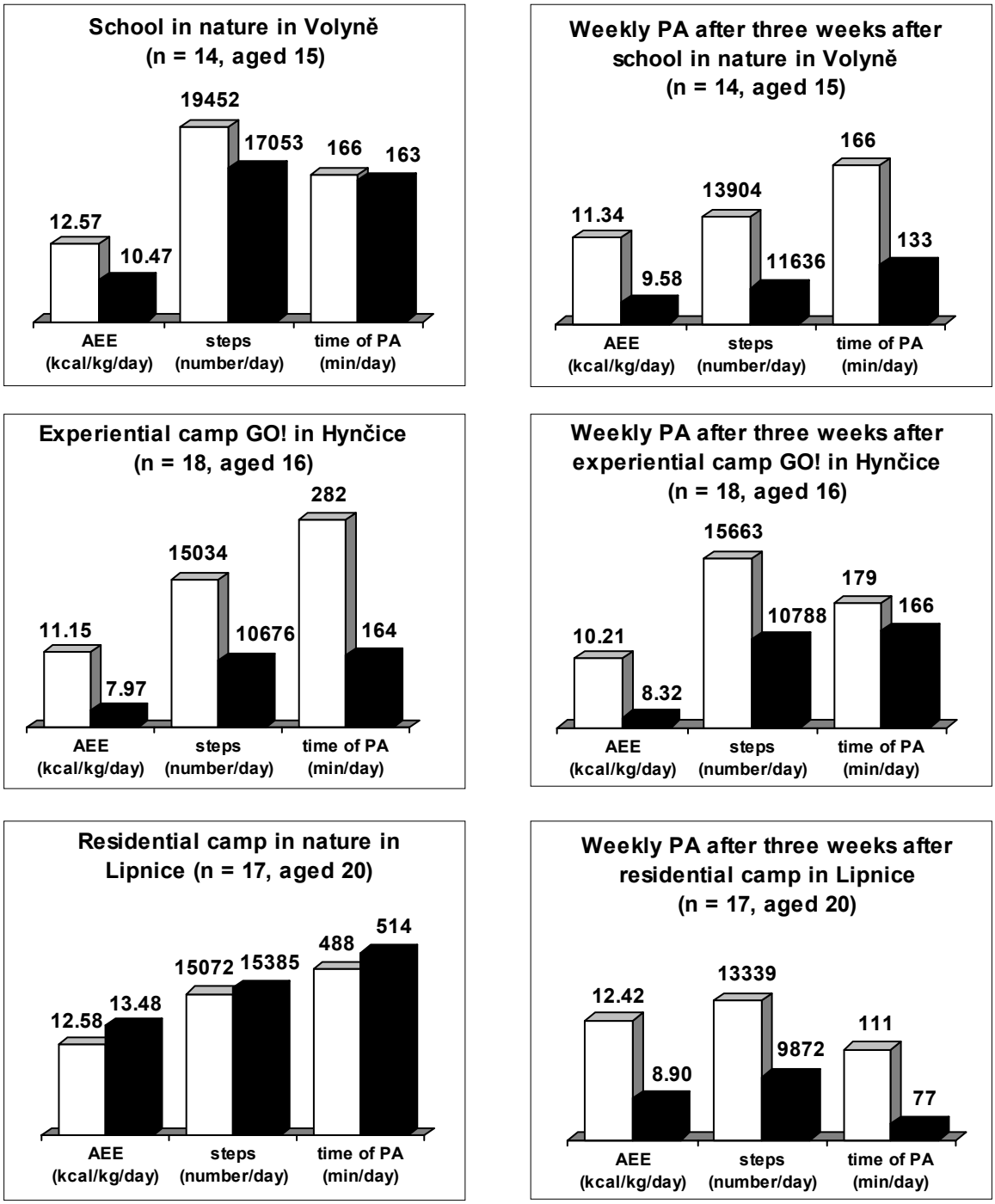
In both females and males of all camps, walking comprises a dominant part of habitual weekly PA (females: 7.8–11.1 $hour \cdot week^{-1}$, males: 6.1–9.3 $hour \cdot week^{-1}$). Walking is followed by sports and other movement games and such types of PA, which can be more easily performed outdoors, in free time, after school, but in the frame of an altered school schedule as well. The preservation of a traditional "walking" environment and the development of a "cycling" environment are economically and ecologically the least demanding of ways of supporting everyday kinetic health prevention in children, youth and adults. Even though an increasing living standard is attended with an increase in physical inactivity and "motorization" (Colditz, 1999), it is very necessary to preserve and support this "walking behaviour" (Eyler, Brownson, Bacak, & Housemann, 2003). Especially support of walking and other types of PA of moderate intensity can reduce the aged-related decline of PA in young females (Leslie, Fotheringham, Owen, & Bauman, 2001).

LIMITATION

One of the limits was that we monitored the effect of "interventional" PA at residential camps in nature only once – within three weeks after the camp finished. For future studies we recommend carrying out long-term monitoring of the duration of the effect of "interventional" PA on habitual PA. An effect of „interventional" PA was confirmed in healthy adolescents, whose attitude towards PA is positive. A world-wide question is how to motivate people, who are not inclined toward PA,

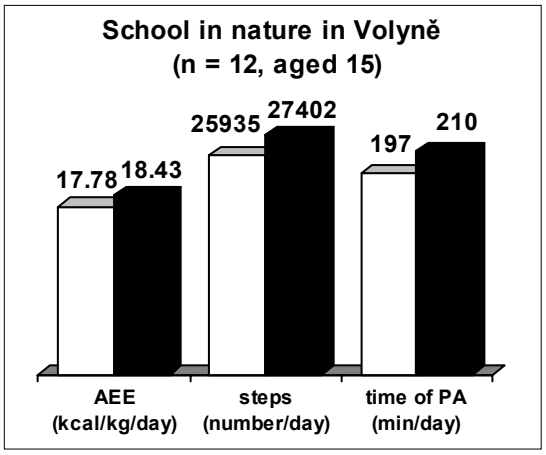
to enhance their PA. There was a seasonal influence – the monitoring of PA took place in the months with better climatic conditions for everyday performance of outdoor PA (Pivarnik, Reeves, & Rafferty, 2003; Pratt, Macera, & Blanton, 1999). From the standpoint of year-long PA, it is convenient to put "interventional" PA also into the time period November–March, which includes months with decreased PA, due to the worse climatic conditions (Pivarnik, Reeves, & Rafferty, 2003; Pratt, Macera, & Blanton, 1999).

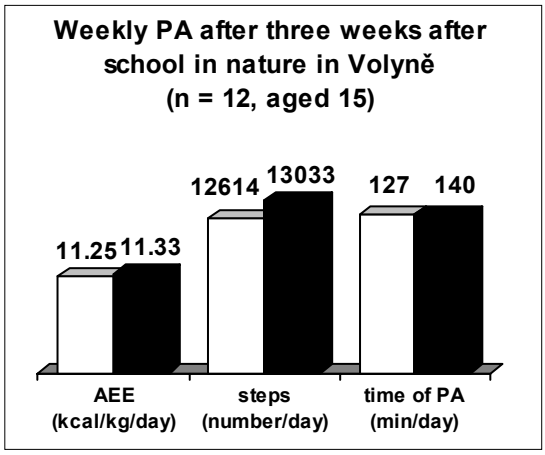
Fig. 1
Comparison of females PA on residential camps in nature and weekly routine

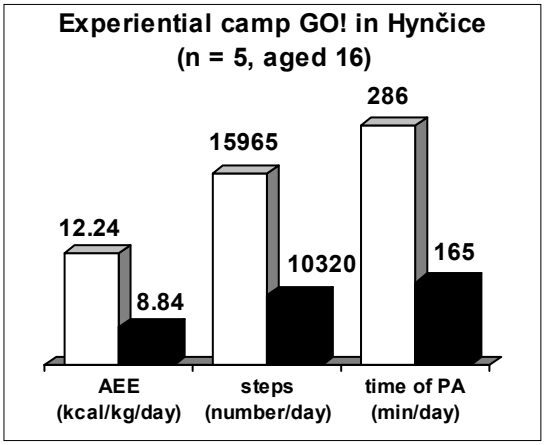


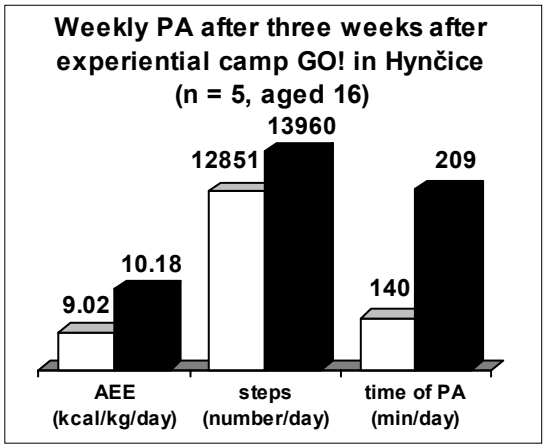
Notes: ☐ workdays, ■ weekends, AEE – active energy expenditure, PA – physical activity

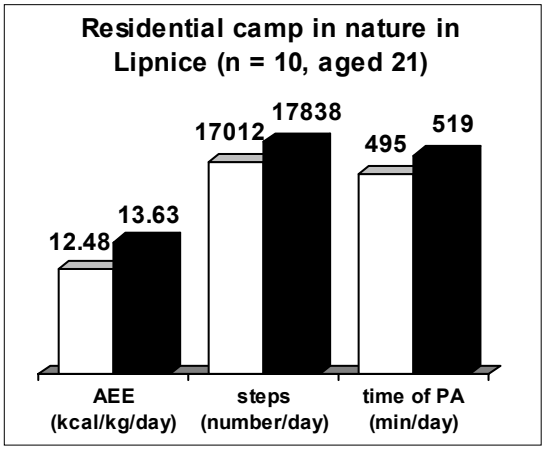
Fig. 2
Comparison of males PA on residential camps in nature and weekly routine

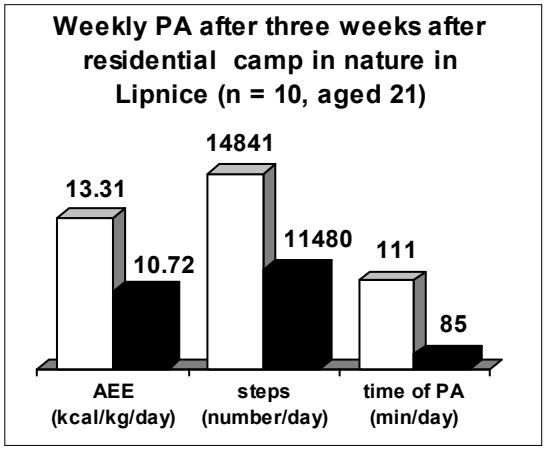












Notes: ☐ workdays, ■ weekends, AEE – active energy expenditure, PA – physical activity

CONCLUSIONS

- Physical activity performed at all analysed residential camps in nature provides not only conditions for health preservation, but by means of its engaging content and form it also erases differences in physical activity between females and males and between weekend and working days.
- Physical activity performed at the school in nature in Volyně and at the residential camp in Lipnice nad Sázavou provided a strong impulse for the development of their fitness in both females and males.
- The highest effect of "interventional" physical activity on habitual weekly physical activity was proved in males ($r_P = 0.60$) and females ($r_P = 0.55$) at the school in nature in Volyně and moderate effect in females ($r_P = 0.39$) at the experiential camp GO! in Hynčice pod Sušinou.
- Residential camps in nature provide suitable conditions for acquiring and fixating movement skills and for acquiring motion experience by means of well-known and uncustomary, team or individual movement and sports games.
- Field monitoring of physical activity based on the triangulation approach to the measurement of physical activity (active energy expenditure – the accelerometer Caltrac, number of steps – the pedometer Omron and time of duration, type and frequency of physical activity and physical inactivity – the individual record) is an appropriate means for assessing physical activity in relation to health recommendations.

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VLIV INTERVENČNÍ POHYBOVÉ AKTIVITY POBYTOVÝCH KURZŮ V PŘÍRODĚ NA HABITUÁLNÍ POHYBOVOU AKTIVITU ŽEN A MUŽŮ

(Souhrn anglického textu)

Hlavním cílem této studie je posoudit vliv pohybové aktivity (dále PA) pobytových kurzů v přírodě na habituální týdenní PA a srovnat úroveň její realizace se zdravotními epidemiologickými doporučeními. Efekt PA pobytových kurzů v přírodě (adaptační kurz GO! v Hynčicích pod Sušinou, kurz pobytu v letní přírodě v Lipnici nad Sázavou a škola v přírodě ve Volyni) byl u žen (n = 49) a mužů (n = 27) posuzován srovnáním s jejich habituální týdenní PA realizovanou tři týdny po skončení pobytových kurzů v přírodě. PA byla monitorována prostřednictvím akcelerometru Caltrac, pedometru Omron a individuálního záznamu. PA byla hodnocena podle aktivního energetického výdeje (Caltrac), počtu kroků (Omron) a doby trvání PA (individuální záznam). Na všech analyzovaných pobytových kurzech v přírodě

splňuje objem PA epidemiologická doporučení k upevnění zdraví. Svým obsahem a formami její provádění také smazává rozdíly mezi PA děvčat a chlapců a PA ve víkendových a pracovních dnech. PA ve škole v přírodě ve Volyni a na kurzu pobytu v letní přírodě v Lipnici nad Sázavou je navíc u děvčat i chlapců výrazným stimulem pro rozvoj tělesné zdatnosti. Výrazný vliv „intervenční" PA na habituální PA byl prokázán u děvčat (r_P = 0.55) i chlapců (r_P = 0.60) ze školy v přírodě ve Volyni a střední efekt (r_P = 0.39) u děvčat z adaptačního kurzu GO!.

Klíčová slova: aktivní energetický výdej, kroky, pracovní dny, víkendy, akcelerometr Caltrac, pedometr Omron.

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First line publications

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SHOULDER BANDAGE WITH DISTAL TRACTION – APPLICATION TO ATHLETES OVERUSING "OVERHEAD" ACTIVITIES

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Sportsmen with overhead activities very frequently have an increased mobility of the shoulder joints. Thus it is often difficult to distinguish between stability, hyperlaxity, and instability of the joint. Repeated extreme movements strain static stabilizers and lead to their lengthening. The principal problem in sporters is to establish a balance between the mobility and stability of the shoulder joint. Clinical examinations and the following treatment should be focused not only on pain but also on the stability of the glenohumeral joint. We can encounter a whole range of possibilities from glenohumeral instability to the impingement syndrome. We often find a narrowing of the subacromial space in so-called tennis shoulder (rotation of the scapula and relative abduction of the humerus). A helpful therapeutic solution of this problem should be provided by a bandage of our own new construction.

The shoulder bandage consists of an upper arm sleeve and an elastic strap leading across the axilla and fixed around the chest. If the upper extremity is free in adduction, there is no tension to the sleeve but in the moment of abduction, the elastic strap is gradually stretched and the sleeve pulls the proximal humerus down. Greater elevation and greater tension can be modified by the tightening or lengthening of the elastic strap. On the one hand the bandage causes broadening of the subacromial space, on the other hand muscle activity is modified and a higher muscle tonus increasingly stabilizes the joint. This paper describes the effect of the bandage from different points of view – orthopedic, biomechanical, and imaging.

A group of 25 patients is evaluated. The feeling of an increased stability of the shoulder is described by 16 sporters and minimizing of pain by using the bandage is reported by 13 sporters. Constraining of locomotion in the edge position is claimed by 18 persons and decreasing of performance resulting from a slowed up lifting of the arm is declared by 16 persons. 9 sporters use the bandage regularly, 8 use it only in case of problems, 6 persons stopped using it after remission of acute complaints, 2 persons claim no effect of the bandage.

The shoulder bandage increases glenohumeral stability, minimizes the risk of injuring the rotator cuff, reduces the risk of impingement syndrome, alleviates or even eliminates the pain in elevation and in extreme positions of the upper arm. It enables sporters to continue sports activities without the risk of worsening a pathological condition.

Keywords: Overhead activities, painful shoulder, bandage with distal traction.

INTRODUCTION

Painful shoulder is a very frequent disorder in practically all sports disciplines. However, incidence of the condition is substantially higher in sports overusing overhead activities. Such sports involve especially ball games including racquet games (tennis, badminton, squash, pelota etc.), throwing events, swimming and artistic gymnastics. In these sports, the subacromial space is considerably overused. As a result, painful disorders are developed. They may be triggered by frequent overhead position of upper extremities and also by hypermobility of the joint, due to the mechanism of frequent swings associated with moving upper extremities to the extremes of motion. These repeated microtraumas develop into a whole range of changes. The articular capsule becomes lax, which gradually leads to development of glenohumeral instability. They may result in subluxating position in the glenohumeral articulation. They may end in impressions of the humeral head having a character of the Hill-Sachs lesion, even if there was no previous history of complete luxation. In the subsequent stage, the impingement syndrome develops. An increased pressure in the subacromial space irritates soft tissues – the amount of fluid between the layers of the subdeltoid fascia is increased, subacromial bursitis is developed, and the next stage is overloading of the rotator cuff, particularly the supraspinatus tendon. What was initially an inflammatory reaction is gradually transformed into degenerative changes that can end in an irreversible damage to the rotator cuff.

These complaints are very often accompanied by muscular imbalances. Especially shortening of the levator scapulae and the upper portion of the trapezoid muscle leads to rotation of the scapula by ever increasing traction in a proximal direction (in the interior angle of the scapula). The resulting distalisation of the acromium leads to an increase in subacromial hyperpressure. The changed position of the scapula and excessive strain in sports, also lead to overloading of acromioclavicular articulation. Other causes can become a source of complaints less frequently. We should never overlook neurogenic and especially vertebrogenic disorders and the possibility of pain transmission occurring as a result of a cardiac or pulmonary alteration. Therefore, it is necessary to exactly establish causes of complaints. In addition to a very careful clinical examination, focused on evaluating the range of passive and active motions as well as glenohumeral stability, it is vital to examine surrounding muscles to rule out any muscular imbalances. Routinely, the shoulder soft tissues must be examined echographically both in basic views and in stressed positions, in which any glenohumeral instability can be shown with a high accuracy. X-ray or neurological examinations are considered complementary, as are examinations by an internist (cardiologist, chest physician) in high-risk patients. The purpose of this work is to present the first results of impingement syndrome treatment in sporters undergoing conservative therapy using an bandage of their own design with a distal elastic tension.

AIM OF THE WORK

In 1994 the authors designed a shoulder bandage with a distal traction in reaction to the fact that the market did not offer any other suitable aid, which could improve glenohumeral joint stability and, at the same time, decrease the pressure in the subacromial space when the upper extremity is positioned above the horizontal line. At the beginning only individual aids were made. Since 1999 they have been applied more often thanks to their positive effect. The aim of this work is to analyse the bandage from clinical and biomechanical viewpoints.

MATERIAL & METHODS

Biomechanical characteristics:

The glenohumeral joint is a shallow ball-and-socket joint. Mechanically it has the character of plane connection. A closed ball-and-socket joint has the character of a spherical connection, but as a result of its shallow socket, the shoulder joint has a flat connection. The position of its individual components in the connection is labile.

No mechanical motion can occur if the resultant force line of action of the shoulder muscular system passes through the potential contact area in a normal direction (it is perpendicular to the joint tangent at the point of contact). Motion equilibrium is then ensured by the contact force in the socket that in magnitude equals the resultant force of the muscular system, but with the opposite orientation and they both lie on the joint line of action.

The action of force in the shoulder joint can be divided into three groups:

a) the action of force in the contact between the humerus and the socket,
b) the action of force associated with usual activities of the muscular system,
c) the action of force associated with excessive activities of the upper arm (sports activities such as hitting a ball in volleyball, strokes with a racquet, shooting baskets in basketball, etc.).

Ad a) First of all we are going to deal with a state in which the shoulder articulation system is in stable equilibrium (mechanical rest) and the action of force associated with the activity of the upper limb is not substantial. The weight of the upper limb is not considered either. Thus the system to be described consists of the force system associated with the activity of the group of muscles and resolved action of force in the contact between the humerus and the socket.

Ad b) The system of muscles represents an adaptive controlled system. Therefore, the action of forces associated with the system of muscles is considered as primary – active, whose action results in the resolved action of force in the contact between the head and socket of the shoulder joint.

A mobile equilibrium between the humerus and the socket will take place, if the resultant of the system of forces from muscles and the resultant of the resolved action of force lie on the same line of action, are of the same magnitude but of opposite orientation, while the line of action of the force is a joint normal at the point of contact (Fig. 1). The normal at the point of contact is perpendicular to the common tangential plane at the point of contact. Thus, the common line of action is determined by geometry of the humerus and the socket at the point of contact. The resultant force of the system of muscles is the action force that need not meet the given condition at a certain moment. Fulfilment of the condition depends on the reaction time of the control system. Its duration is usually very short and thus the position of the socket and humerus is not substantially changed and the contact occurs in a physiologically viable position.

Ad c) So far we have dealt with the case in which upper limb activity is not decisive. Now the focus will be on

the action of force in the shoulder joint with significant activity of the upper arm in sports, where the upper limb is active in overhead positions. This activity involves, in addition to the above mentioned action of forces, inertial forces and also the action of forces involved in the sports performance itself, i. e. the one associated with strokes of a different character, such as direct hand strokes in volleyball, strokes with racquets in tennis or squash or ball shooting in basketball or handball. In all these activities the impact forces have, in comparison with the above mentioned forces, a several times greater magnitude with a short duration. Both facts act adversely on the shoulder joint function. If the action of impact forces is shorter or equals the reaction times of the muscle system, then its reaction lacks the time to provide such a ratio of forces as could ensure dynamic conditions of balance. It means that the resultant's line of the action of force associated with the sporting activity and muscle group does not have its normal direction at the points of contact. Besides a normal component it has a tangential component as well. In this instance the character of the system of forces is beyond control, and the resultant's line of action passes beyond the area of possible contact of the socket with the humerus. The humerus is translated into a non-functioning position. However, it must be said that during this activity the tangential component is heading upwards and thus the humerus head is translated upwards and thus subacromial hyper pressure may occur (Fig. 2, the outline).

In thid analysis we are going to consider arbitrary motion of the upper limb, including the motion in which overloading by activities occurs. It is a case of a concrete state of motion determined by the position, speed and acceleration of the upper limb. In the given state, the forces involved in all elements affecting the motion of the upper limb and the force associated with its activity will assume a certain, entirely concrete value. A dynamic task, which is defined in such a way, will be formally transformed into a static one by introducing inertial forces and moments on the basis of d'Alembert principle.

Due to the fact that any entirely determined force system from the point of view of static equivalence can be replaced by a force and a force couple, determined at the moment, it is possible, using a gradual statically equivalent substitution, to express actions of other elements of the upper limb at an arbitrary point of the elbow joint via a force and moment resultant, determined at the moment.

Now, the arm can relax. Force elements acting on a relaxed arm can be formally divided into:

- forces and force moments in muscles and other tissues ($\mathbf{F}_{VO}$, $\mathbf{M}_{VO}$),
- inertial forces and moments ($\mathbf{F}_{A}$, $\mathbf{M}_{A}$),
- force and moment resultants of the relaxed parts of the upper limb acting in the elbow joint ($\mathbf{F}_{VL}$, $\mathbf{M}_{VL}$),
- force and moment resultants in the shoulder joint ($\mathbf{F}_{VR}$, $\mathbf{M}_{VR)}$.

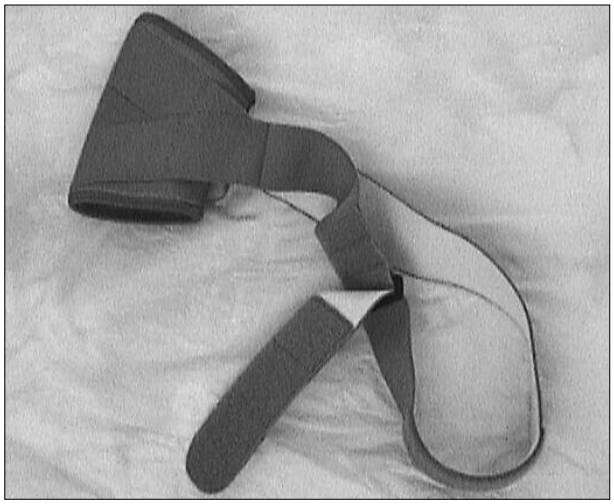
Then the equilibrium equation can be expressed in the form:

$$\mathbf{F}_{VO} + \mathbf{F}_{A} + \mathbf{F}_{VL} + \mathbf{F}_{VR} = \mathbf{0}$$
$$\mathbf{M}_{VO} + \mathbf{M}_{A} + \mathbf{M}_{VL} + \mathbf{M}_{VR} = \mathbf{0}$$

Now a mechanical analysis of the shoulder joint will be made. The shoulder joint is an open ball-and-socket joint. From the mechanical point of view it has the character of a flat, conditionally functional coupling. (The joint is functional if the resultant contact force is directed into the joint.) In a physiologically developed joint, the passive constraints (friction) are not substantial, which is manifested by a zero moment resultant ($M_{VR} = 0$) and perpendicularity of the carrier of the force resultant F_{VR} to the common tangent plane in the point of contact.

Thus $M_{VO} + M_{A} + M_{VL} = 0$
and if we denote $F_{VO} + F_{A} + F_{VL} = F_{V}$,
then $F_{V} = F_{VR}$

Fig. 1
The muscular system represents a controlled system, therefore if it is not overloaded, it ensures that the above conditions can be satisfied without any problems



In case of overloading, the force resultant is directed against the upper edge of the glenoid fossa and the humerus head is translated in the same direction until it is subluxated and strikes the soft tissues, which causes pain and a gradual development of pathological changes. The change in the direction of force resultant $\mathbf{F}_{V}$ can be achieved by adding force $\mathbf{F}_{p}$ (Fig. 2) that is, in our case, exerted by the shoulder orthosis. As seen in the figure, force $\mathbf{F}_{p,}$ must have a direction and magnitude within

a certain range, which provides variability of the shoulder orthosis. Using appropriate parameters of force $\mathbf{F}_p$, the altered resultant $\mathbf{F}_{Vp}$ will have the same direction as if it were not overloaded and so no displacement of the humerus head occurs.

Fig. 2

DESCRIPTION OF THE BANDAGE

The new type of bandage is based on an innovative design concept. It consists of an atypical design and overall construction as well as a new combination of materials. The sleeve, extended over the proximal arm, is made of a special breathable material, Syncrolast, which does not cause any sores after round-the-clock wearing (Fig. 3). It is fixed to the thoracic wall by means of a stretchable, rubber traction over the axilla. If the arm hangs freely, there is no traction exerted on the fixed arm sleeve and the orthosis does not have any effect (Fig. 4). When the arm is elevated, the elastic traction is gradually stretched and the sleeve pulls the proximal arm in a distal direction towards the chest (Fig. 5). The greater the elevation of the arm, the greater is the distal pull and hence the greater unloading of the subacromial space. The traction can be adjusted by tightening or loosening of the fixation to the chest wall by sliding velcro fastening.

Fig. 3

Fig. 4

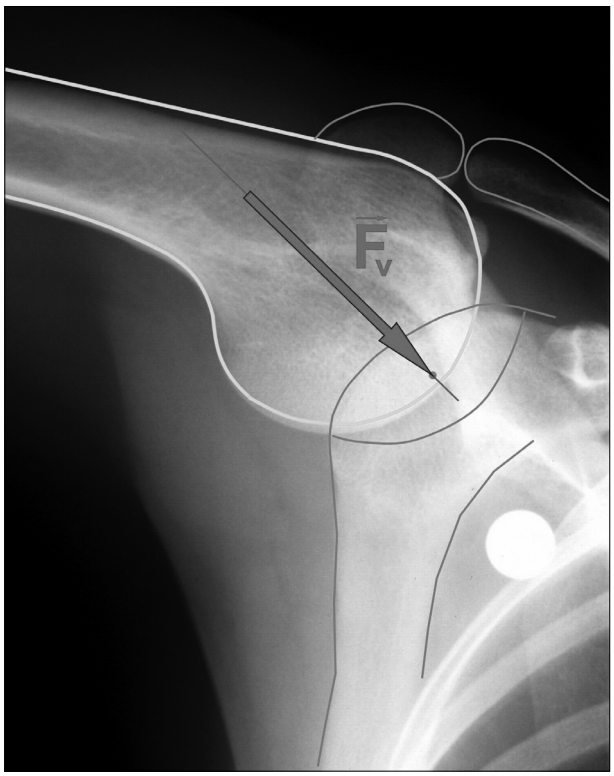
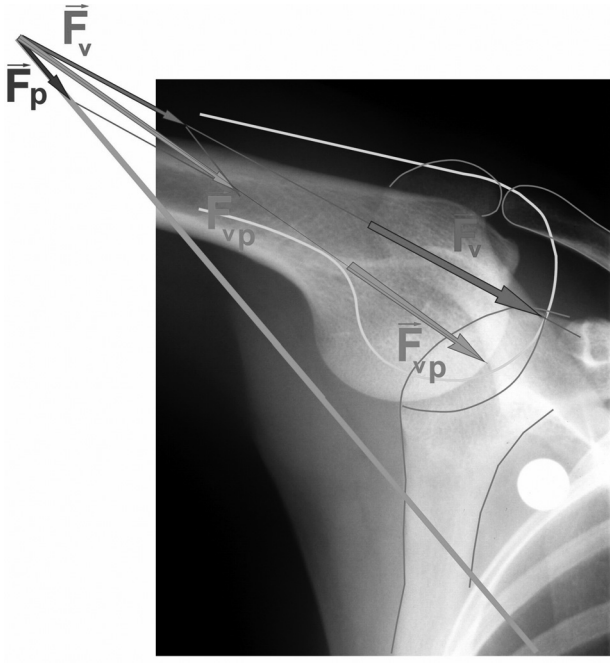


Fig. 5



X-ray and USG examinations

To verify the effect of the orthosis, X-ray examination was performed by means of skiagraphic device Argostat plus HF50R and ultrasound examination by means of Medison Sono ACE.

Images were realized both without and with the bandage.

X-ray examination: To evaluate the skiagrams objectively, a calibration pellet was attached to the patient's body. The skiagrams were taken at a standard distance and position to rule out any distortion. Subsequently the subacromial space, imaged on the skiagrams, was compared.

In the skiagram with a fitted orthosis, the width of the subacromial space increased by 20% (Fig. 6). Comparative images are performed routinely, that is why the ethical committee's consent was not required.

USG examination: The distance between the outline of the humerus head and the acromial border was compared in the standard position of the upper extremity and echographic probe (lateral longitudinal view) (Fig. 7). The results of measurement corresponded with the X-ray findings.

Fig. 6

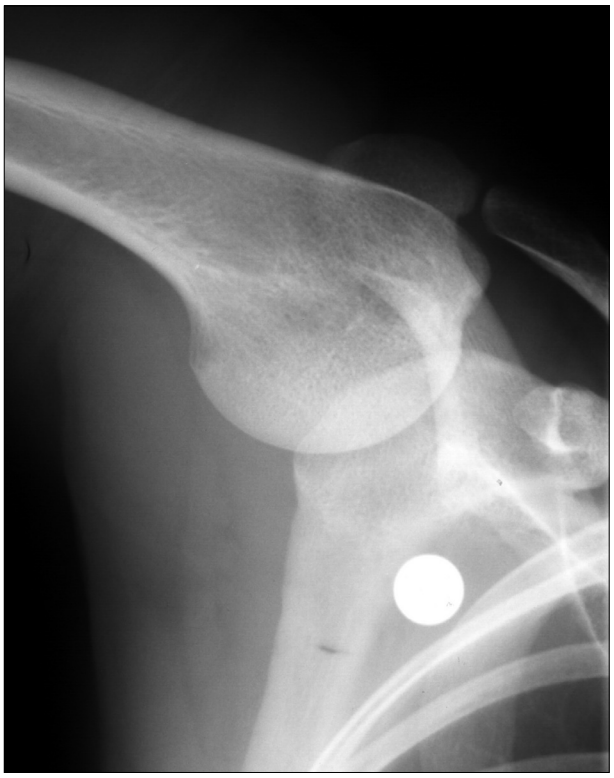
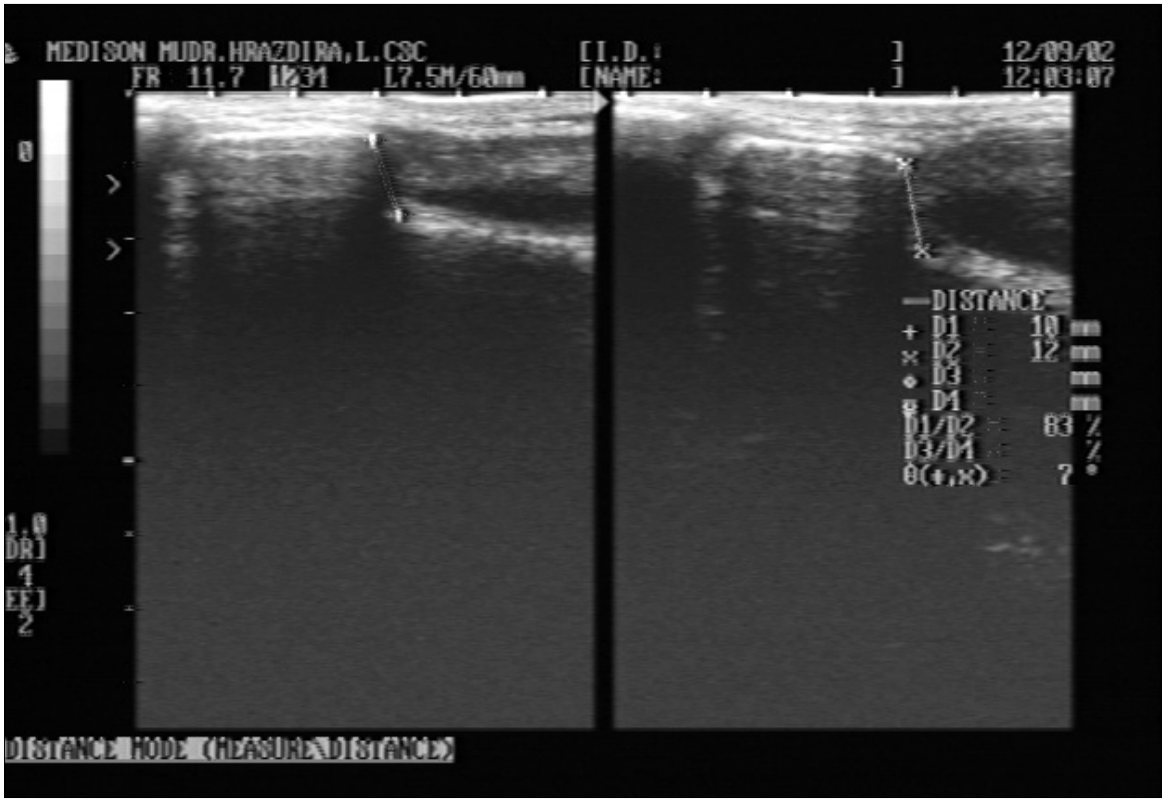


Fig. 7



Group of patients

The shoulder orthosis was fitted in 25 athletes clinically diagnosed with impingement syndrome. We monitored its effect on soreness, seriously restricted range of motion and change of biomechanics in the shoulder girdle, ability to improve stability of the glenohumeral joint and patients' subjective feelings with or without a bandage.

RESULTS

All 23 subjects reported subjective alleviation of pain and 2 persons reported no effect of the bandage. A subjective feeling of shoulder strengthening and an increase in stability was confirmed in 16 subjects. The sensation of restricting motion in extreme positions was stated by 18 subjects. A feeling of limitation in performance as a result of slowing during wind up and cocking is claimed by 16 athletes.

In 16 athletes, the bandage must be worn for sport, 9 wear it intermittently, 8 stopped wearing it when their acute complaints subsided, 2 athletes do not use it due to allegedly zero effect.

DISCUSSION

As the bandage is of a completely new design, it cannot be compared with other cases known in literature. The bandage distalises the humerus head. It reduces the risk of increase in pressure in the subacromium when the arm is lifted above the horizontal line and thus reduces the possibility of the development of (primary) impingement syndrome. It acts as an antagonist to the supraspinatus, which is the primary depressor of the humerus. At the same time it reduces demand on the long head ligament of the biceps and decreases the strain of the lower glenohumeral ligament. By its pull, the orthosis reduces the risk of rotator cuff injuries against the distal side of the coracoacromial arch and the risk of secondary impingement syndrome development. It also acts against the development of secondary impingement syndrome by translating pressure over the humerus into the socket of the glenohumeral articulation. It lends higher stability to the joint and reduces the risk of translating positions of the humerus head. Simultaneously, tonus of the muscles is raised in the shoulder girdle by a double mechanism. On the one hand, muscles are stimulated to develop a higher activity to actively overcome the resistance in elevating the arm above the horizontal line. On the other hand, the bandage fitting in itself modifies proprioceptive innervation. The continuous stimulation of exteroceptors by the bandage produces

sensoric impulses in afferent neurons travelling to the posterior spinal-chord, interneurons excite impulses in motoneurons of one or more segments, which results in a certain reflexive response. Weak stimulation and repeated stimuli then lead to an increased muscular tonus or to a tonic reflexive response (reflexive activity on the spinal cord level). Simultaneously, the increased tonus of periscapular muscles and the increased pressure of the humerus head against the scapula will reduce the risk of developing scapulothoracic instability.

CONCLUSION

A shoulder bandage with distal traction enables sporters to continue sports activities without the risk of worsening the impingement syndrome. It improves stability of the glenohumeral articulation, alleviates or even eliminates pain during arm elevation by reducing the pressure in the subacromial space.

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RAMENNÍ ORTÉZA S DISTÁLNÍM TAHEM – POUŽITÍ VE SPORTOVNÍ MEDICÍNĚ U PŘETÍŽENÍ „OVERHEAD" AKTIVITAMI

(Souhrn anglického textu)

Autoři předkládají první výsledky léčby impingement syndromu u sportovců léčených konzervativně pomocí ortézy vlastní konstrukce, s distálním elastickým tahem.

Ramenní ortéza byla naložena u 25 pacientů – sportovců s diagnózou impingement syndromu. Byl sledován vliv na bolestivost, závažnost omezení rozsahu pohybu a změnu biomechaniky pletence ramenního. Dále schopnost zvýšit stabilitu glenohumerálního skloubení a subjektivní pocit sportujícího pacienta.

Nový typ ortézy spočívá v netradičním pojetí konstrukce. Krátký rukáv, který je z elastického materiálu, je natažen na proximální paži. Pomocí pružného gumového tahu je fixován k hrudní stěně. Pokud horní končetina volně visí, není žádný tah za fixovanou pažní manžetu. V okamžiku elevace končetiny dochází k postupnému napínání gumového tahu a manžeta stahuje proximální paži směrem distálním. Čím větší je elevace končetiny, tím větší je tah distálním směrem a odlehčení subacromiálního prostoru. Tah je možno modifikovat přitažením nebo uvolněním upnutí fixace na hrudní stěnu.

Subjektivně udávané zlepšení bolestivosti při sportu je u 23 pacientů, ve dvou případech nemá ortéza žádný efekt. Subjektivní pocit zpevnění ramene a zvýšení stability prokazujeme u 16 sportovců. Pocit omezení hybnosti v krajní poloze udává 18 jedinců. Pocit snížení výkonnosti v důsledku zpomaleného nápřahu je u 16 jedinců.

Potřeba nezbytnosti užití ortézy na sport je u 6 jedinců, 9 používá ortézu intermitentně, 8 po odeznění akutních potíží ortézu odložilo, 2 pro nulový efekt nepoužívají.

Vzhledem k tomu, že se jedná o zcela nový charakter bandáže, nelze komparovat se zkušenostmi v literatuře. Ortéza distalizuje hlavici humeru. Snižuje riziko vzniku zvýšeného tlaku subakromiálně při elevaci paže nad horizontálu a tím rozvoje (primárního) impingement syndromu. Působí jako agonista m. supraspinatus, který je primárním depresorem hlavice pažní kosti. Současně snižuje nároky na šlachu dlouhé hlavy bicepsu a snižuje napětí dolního glenohumerálního vazu. Ortéza svým tahem snižuje riziko poranění manžety rotátorů o distální stranu korakoakromiálního oblouku a snižuje riziko vzniku sekundárního impingement syndromu. Proti vzniku sekundárního impingement syndromu působí i tlakem přenášejícím se přes pažní kost do jamky glenohumerálního skloubení. Zvyšuje se stabilita kloubu a snižuje riziko translačních poloh hlavice humeru. Současně dvojím mechanismem dochází ke zvýšení svalového tonu v oblasti pletence pažního. Jednak aktivním

překonáváním odporu při elevaci paže nad horizontálu jsou svaly nuceny ke zvýšené aktivitě, dále již samotné naložení bandáže mechanismem modifikace proprioceptivní inervace – trvalé dráždění exteroreceptorů bandáží vyvolá senzorické vzruchy v aferentních neuronech jdoucích do zadních provazců míšních, interneurony vybaví vzruchy v motoneuronech jednoho či více segmentů a dojde k reflexní odpovědi, slabé dráždění a opakované podněty pak vedou ke zvýšení svalového tonu resp. k tonické reflexní odpovědi (reflexní činnost na úrovni míchy). Zvýšený tonus periskapulárních svalů i zvýšený tlak hlavice humeru proti lopatce současně snižuje riziko rozvoje skapulotorakální instability.

Bandáž ramena s distálním tahem umožní pokračovat ve sportovní aktivitě bez rizika prohlubování impingement syndromu, zvýší stabilitu glenohumerálního skloubení, zmírní až odstraní algie v elevaci paže snížením tlaku v subacromiálním prostoru.

Klíčová slova: overhead sportovní aktivity, bolestivé rameno, ortéza s ditálním tahem.

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ALTERNATIVE RESEARCH STRATEGIES IN THE EXERCISE – MENTAL HEALTH RELATIONSHIP

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From the numerous investigations available, there is cautious support for the proposition that exercise is associated with enhanced emotion and mood in mental illness, but the strength of the conclusions derived from the empirical findings available will largely depend on the strength of the designs applied. In applied research, such as the investigation of the exercise – mental health relationship, this relationship depends on population, environmental and individual characteristics and a number of difficulties will certainly hinder progress in this area of inquiry. Randomised controlled trials are important but have the disadvantage of deemphasizing the importance of the individual. Single-case designs on the other hand have considerable potential to adequately unravel the mechanisms at work in the exercise – mental health relationship.

From a clinical perspective however, research findings should be viewed based on the support of earlier epidemiological evidence, suggesting that mental illness indeed might be associated with low activity/fitness and that those who maintain activity are less likely to develop mental illness.

Keywords: Exercise, mental health, randomised controlled trials, single-case designs.

INTRODUCTION

Exercise has been suggested as an effective adjunctive treatment for a wide range of mental health conditions, such as depression, anxiety and schizophrenia, leading to cautious optimism regarding the potential efficacy of exercise as a therapeutic possibility. In the case of clinical depression, it has been concluded that (a) exercise significantly decreases depression, and the antidepressant effects persist in time (from 2 months to 1 year); (b) all modes of exercise are effective; (c) the longer the exercise program, the greater the decrease in depression; and (d) exercise is at least as effective as psychotherapy (Brosse et al., 2002; Craft & Landers, 1998; Lawlor & Hopker, 2001; O'Neal, Dunn, & Martinsen, 2000). Similar findings have been reported for anxiety, although fewer studies are available due to the difficulties in defining "anxiety" at the clinical level. Additionally, it is recommended to lower exercise intensity because this might be largely responsible for elevated recidivism (O'Connor, Raglin, & Martinsen, 2000; Petruzello et al., 1991; Raglin, 1997). Exercise also seems to be a useful adjunct in the treatment of some of the negative symptoms of schizophrenia (Faulkner & Biddle, 1999). Evidence for the use of exercise in the treatment of other mental illnesses is hard to find (Biddle & Mutrie, 2001). The reader is referred to, e. g. Biddle et al. (2000), Biddle and Mutrie (2001) and Landers and Arent (2001) for recent overviews of research findings.

Some of the existing research, however, has led to cautious conclusions about how much benefit physical activity and exercise might have (Landers & Arent, 2001; Leith, 1994; Morgan, 1997). Different reviewers mention that this might be due in part to the inadequacy of research designs and assessment procedures (Lawlor & Hopker, 2001; Morgan, 1997; Biddle & Mutrie, 2001). It has been suggested previously (Leith, 1994) that as experimental rigor improves, the positive effects of exercise become less obvious, although the smaller number of true experimental studies make it difficult to be confident about such a conclusion. However, the observation that both field and laboratory research report the same beneficial effects of exercise can only strengthen the position that exercise has excellent potential to impact positively on mental health in clinical populations.

In this overview, we discuss the quality of the evidence in the exercise – mental-health relationship reviewed and we suggest complementary strategies. Treating patients suffering from severe mental illness is a very complex issue and cannot be reduced to a few guidelines. In the end of the article, an effort will however be made to translate the current scientific knowledge into proposals for evidence-based interventions.

RESEARCH LIMITATIONS

Random selection of participants and random assignment to treatments is the most effective means of controlling threats to internal and external validity, while the inclusion of a control group rules out the possibility that something other than the experimental treatment (i. e. exercise) has influenced the outcome. The studies of Blumenthal et al. (1999) and Broocks et al. (1998) are good examples of evidence-based support for the efficacy of physical activity as an adjunctive treatment for clinical depression or anxiety, since the evidence is gathered through such randomised controlled trials. Blumenthal et al. (1999) compared the effects of physical activity treatment and drug treatment in a sample of 156 men and women meeting DSM-IV criteria for major depressive disorder. The participants were randomly assigned to (a) a physical activity group consisting of three 30-min supervised physical activity sessions per week (cycle ergometry or brisk walking/jogging at 70–85% heart rate reserve); (b) antidepressant medication; or (c) a combination of both previous conditions. After 16 weeks, all groups exhibited significant reductions in symptoms of depression and there were no significant differences across groups. Broocks et al. (1998) compared the therapeutic effect of exercise for 46 patients with panic disorder, randomly assigned to a 10-week treatment protocol of (a) regular aerobic exercise (gradual prolongation of 3 running periods per week); (b) medication; or (c) placebo pills. In comparison to placebo, both exercise and medication led to a significant decrease in anxiety and depressive symptoms according to all main efficacy measures. A direct comparison of exercise and medication revealed that the drug treatment improved anxiety symptoms significantly earlier and more effectively.

Unfortunately, the strength of the conclusions derived from the empirical findings available is too often limited since a number of difficulties exist. These include methodological problems (e. g. poor statistical power because of small samples, inadequate study design, absence of control groups, absence of randomised trials, differing methods of measuring outcomes), as well as effects of non-specific factors that might be responsible for at least part of the effect (e. g. placebo and expectation effects, time in contact with professionals under different treatment conditions, empathy and attention from the exercise leader, spontaneous recovery).

One of the most obvious shortcomings always has been inappropriate subject selection. Much of the research to date has examined the effect of exercise on mental health in subject samples that might derive benefits from exercise, but do not meet the initial criteria of "clinical" proportions of mental illnesses as diagnosed by e. g. DSM-IV (Diagnostic and Statistical Manual of Mental Disorders, American Psychiatric Association, 1994). In case of, e. g. clinical depression, a number of individual studies and reviews include populations of individuals who were depressed as a result of a physical health problem (e. g. myocardial-infarction, Kugler et al., 1994) or as a result of more temporary mood swings (e. g. feelings of depression in college students, North et al., 1990). Mutrie (2000) cautions against incorrect interpretations of findings derived from such investigations.

Most empirical studies dealing with exercise and mental health have insufficient statistical power to detect differences that are significant at the conventional levels of probability, mainly due to the fact that true experimental designs are in the minority (Landers & Arent, 2001; Lawlor & Hopker, 2001; Taylor, 2000). The result has been a risk for increase in type II errors. Lawlor and Hopker (2001) aimed to provide a better quality analysis by including only trials that were described as randomised controlled trials. Their results did not differ from those of other meta-analyses that also included non-randomised trials and observational data. In clinical trials it is indeed extremely difficult to find enough patients with the same deficiencies, and possibly the same background, to compose more or less homogeneous groups for making comparisons or to draw conclusions for this population. Furthermore it is not always possible to employ truly experimental designs that take these methodological aspects into consideration. This is particularly the case for patients being treated in a hospital setting, who have been admitted for therapeutic help (Morgan, 1997). As a consequence the effect of randomisation is mitigated by the lack of adequate concealment, intention to treat analysis, and blinding (Lawlor & Hopker, 2001).

It should also be noted that subjects with major to severe mental health problems are rarely studied. Studies with "volunteers" are more common, although it is not always clearly stated that these volunteers are representative of the target population. This especially was the case in the initial investigations in which patients were recruited from the community through volunteer databases (e. g. Singh et al., 1997) or when they agreed to participate (e. g. Sexton et al., 1989). Especially in the case of physical activity, it might be presumed that participants in such investigations believed physical activity to be a credible treatment modality and were as a consequence favourably inclined toward participation (Lawlor & Hopker, 2001). In the United Kingdom rates of compliance with "exercise on prescription" schemes among patients with any referral criteria vary from 20% to 50% (Fox et al., 1997). It is reasonable to assume that compliance among patients suffering from mental illness would be at least similar or even worse. Salmon (2001, 39) already pointed out that "exercise training, which emphasises patients' motivation and responsi-

bility, does not obviously meet the immediate need of such patients". Therapists and clinicians are faced with patients who often have to contend with an absence of motivation to tackle much less strenuous features of life's routine.

It is noteworthy that a number of investigations have failed to observe significant psychological changes as measured by standardized instruments that possess good reliability and validity, despite the fact that participants in these studies reported that they experienced an "increased sense of well-being". It is possible that the enhanced sensations of well-being reported by these individuals reflect changes in psychological constructs other than those assessed in a given study. Suffering from a depressed mood might indeed be the dominant symptom of clinically depressed individuals, but the syndrome of clinical depression is far more complex. Measurement tools may only pick up decreases in negative symptoms and miss out on increases of positive mental health (Van de Vliet et al., 2004).

Most investigations applied measurement instruments, applicable to large scale administration, but these instruments are not appropriate for detecting intra-individual variability. Items that fail to discriminate between groups of individuals have been eliminated during the phases of questionnaire construction. The remaining items tend to represent the extremes of a trait dimension (e. g. depression, anxiety), so that they are not sensitive enough to detect individual changes.

ALTERNATIVE RESEARCH APPROACHES

Based on the present findings, more randomised trials, such as Blumenthal et al. (1999) and Broocks et al. (1998), are needed before poor mental health should be considered to be directly improved through exercise (Biddle & Mutrie, 2001). However, there might be a difficulty in conducting true double blind RCT in therapeutic circumstances. Randomised trials answer "a circumscribed set of questions and issues related to outcome rather than to process, and to efficacy rather than effectiveness" (Roth & Parry, 1997, 370). In other words, we have a (positive) outcome but what actually happened? Besides that, small but consistent changes, which in a group design would not emerge as being statistically significant, can be of major importance for the individual (Hrycaiko & Martin, 1996).

From this perspective, a variety of methodological approaches can be discussed. Such a discussion is often referred to as methodological eclecticism "on the ground that such an approach promises to cancel out the respective weaknesses of each method" in an attempt to contribute to a more definitive answer to this health related issue (Biddle et al., 2001, 778).

Considering guidelines that have been established for evaluating overviews of research evidence and under the condition that appropriate inclusion criteria have been applied, meta-analyses have distinct advantages over individual experiments and enable the researchers to provide further substantial evidence for positive effects (Biddle et al., 2000; Landers & Arent, 2001). The outcome of meta-analytic reviews, however, is subject to the quality of the input (Mutrie, 2000). As mentioned above, too many investigations suffer from, e. g. inappropriate subject selection or too vague inclusion criteria for baseline measurements.

Additionally, there is a need for single-case studies with patient groups in which randomised trials are unlikely to be feasible. This is particularly the case when individual responses to exercise settings and exercise conditions will vary (Fox, 2000). With a focus on applied issues such as the effect of exercise interventions on, e. g. mood disorders, there is a need for a methodology or instrumentation that is sensitive enough to register constancies and idiosyncrasies in emotional and behavioural reactions to the treatment conditions. Mutrie (2000) urges a more individualised approach of how different patients perceive the role of exercise in the treatment of depression, since it is more likely to enable the unravelling of the mechanisms at work. Single-case research might be proposed as such an alternative approach, because it can be applied in almost natural conditions and takes into account all the relevant properties of the setting without violating the canons of disciplined science and practice. Within the framework of clinical research, the tailoring of therapeutic programs, designs and measurements represent a major benefit of this approach. Furthermore, recent advances with respect to the statistical analysis of single-patient data and with respect to the meta-analysis of replicated single-case studies enable the researcher to draw statistically valid conclusions at the individual as well as at the group level (Edgington, 1992; Onghena, 1994; Van den Noortgate & Onghena, 2003).

Different examples are available to justify the choice for more individualised approaches. Faulker and Sparkes (1999) report a qualitative study investigating the effects of a physical activity program on the lives of three individuals with schizophrenia within a residential setting using an ethnographic approach. Triangulation of the different (qualitative) data sources captured a contextual picture of the importance of physical activity in the lives of these individuals. For example, more adequate behaviours were observed on days of physical activity compared to days of physical inactivity. Van de Vliet et al. (2003b) analysed daily mood changes in 29 clinical depressed patients by means of replicated single-subject methodology. Through the application of randomisation tests and time-series analysis no evidence could be found

that adding fitness training to the treatment of clinical depression would systematically lead to changes in self-reported feelings of depression. On the other hand, feelings of physical well-being reduced depressive feelings, but were, in turn, independent of the implementation of the fitness program. These findings clearly point out the complexity of the relationships between different measures related to the exercise – mental health relationship. Given that the experience of physical activity is likely to be unique then, a methodology that accounts for the individual deserves further recognition (Carless & Faulkner, 2003). Using these methodologies, both examples provided analyses and evaluations in a naturalistic treatment setting, which offers new opportunities when working or when deontological conditions make clinical trials more difficult.

A recent case has been made (Mutrie, 2000) that it may be appropriate to use Hill's classic criteria for deciding whether there is an association or a causal link between the observed illness (in this case mental illness) and some environmental conditions (in this case exercise or the lack of it). Hill suggested eight criteria which can be used to help scientists and practitioners decide if a causal interpretation of evidence can be made. Mutrie claims that the research literature with respect to the exercise – clinical depression relationship provides support for all of Hill's criteria: strength of association, consistency, temporal sequence, biological plausibility, experimental evidence, dose-response, coherence and specificity, although Mutrie concluded only "modest" support for the last three criteria. In reaction, Arent, Rogers and Landers (2001) say that though the evidence in favour of a link between exercise and selected mental health variables (e. g. depression, anxiety, mood) continues to mount, it seems premature to conclude that this link is causal in nature. More true experimental research with major focus on dose-response, coherence and specificity is needed, before mental health is considered to be directly altered through exercise.

IMPLICATIONS FOR PRACTICE

Treating severe psychiatric patients is a very complex issue and cannot easily be reduced to a few guidelines. However, increased efforts should be made in order to come to evidence-based interventions. Research findings are indispensable in this respect and continuous vigilance should be given to the translation of research outcomes into therapeutic advise. In Flemish psychiatric hospitals, the application of fitness training in the treatment of depressed patients is imbedded in psychomotor therapy. This therapy attempts to act systematically on body perception and behaviour through movement situations in order to achieve therapeutic objectives related to the psychological problems of the individual patient (Probst & Bosscher, 2001). Based on the present findings some self-enhancement strategies may be derived that can be implemented in psychomotor therapy programs within a multi-disciplinary and individually tailored Cognitive Behavioural Treatment Program (CBTP). The efficacy of the following recommendations obviously must be tested yet in controlled situations.

Exercise interventions seem to be associated with positive changes in different aspects of the patients' functioning and lead to improved self-reported feelings of physical well-being and to reduced feelings of depression in certain cases. Besides that, positive changes in physical self-worth are associated with a relief of depressive symptoms and an enhancement of self-esteem over a three-month period with multidisciplinary treatment (Van de Vliet et al., 2003a). Based on these experiences, self-enhancement strategies can be implemented into psychomotor therapy programs (Van de Vliet, Knapen, & Van Coppenolle, 1999). This approach is largely based on the efficacy theory of Bandura (1977). The starting point is "to give it a try". If this trial is successful, the need to be in interaction improves, being a new impetus for a next trial. The taxation of to what extent the interaction might be considered successful is likely to affect whether a patient will even try to cope with given or new situations. The intervention, in this case psychomotor therapy, can provide the framework in which the individualised therapeutic objectives can be achieved. These strategies include: (1) the creation of success experiences by setting concrete and achievable objectives; (2) the reinforcement of social appreciation for patient, therapist and fellow patient; (3) the evaluation of personal performance; and (4) the improvement of subjective feelings of fitness (Van de Vliet, Van Coppenolle, & Knapen, 1999). Psychomotor therapy that focuses on the development of such positive expectancies and self-enhancement strategies can be hypothesised as very successful in the treatment plan of depressed patients.

Furthermore, since Martinsen, Medhus and Sandvik (1985) also provided evidence that aerobic exercise leads to improvement in – initially very poor – functional capacity levels in depressed patients, benefits of exercise programs are not only to be situated in the area of psychological well-being.

CONCLUSION

Considering the available research evidence in the exercise – mental-health relationship, Mutrie (2000, 60) states that "the potential benefit of advocating" the use of exercise as part of a treatment package for depression far outweighs the potential risk that no effect will

occur. There are very few possible negative side effects (e. g. injury, exercise dependence) and there have been no negative outcomes reported in the literature. In addition, there are potential physical health benefits such as an increase in fitness, weight reduction, and decreased coronary artery disease risks. Therefore, physical activity/exercise should be advocated as part of the treatment for clinically defined depression'. Based on the current evidence available, this statement can be extended as to the treatment of anxiety disorders, and preliminary results in investigations with schizophrenic patients point in a similar direction. However, there is a need for well designed, randomised controlled trials on clinical populations that measure different outcomes. Different pitfalls to be avoided in the design of these trials are outlined in the present paper. On the other hand, the following statement of Fox (2000) indicates the urgent need for further investigation using an eclectic research approach. The effects of exercise are likely to be a very individual experience with each "exerciser" relying on a unique exercise formula for maximum psychological benefit. As a consequence, "outcome-oriented" research, such as randomised controlled trials, should be complemented with "process-oriented" investigations, addressing the question of what actually happened in each single individual. The consideration of alternative methodological approaches can complement the findings of research trials by exploring individuals' experiences of process and effectiveness. This inclusive and complementary approach of different research strategies will not only develop the evidence base but also evidence-based practice (Carless & Faulkner, 2003, 78).

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ALTERNATIVNÍ VÝZKUMNÉ STRATEGIE VE VZTAHU CVIČENÍ – MENTÁLNÍ ZDRAVÍ

(Souhrn anglického textu)

Z početných dostupných šetření jsme zjistili, že existuje malá podpora pro tvrzení, že u osob s mentálním postižením je cvičení spojeno s lepšími pocity a náladou. Navíc síla tvrzení odvozená z dostupných empirických výzkumů bude pravděpodobně záviset na podmínkách konkrétního šetření. V použitém výzkumu vztahu cvičení k mentálnímu zdraví: záleží na populaci, charakteristice prostředí a jednotlivci. Množství proměnných a různých obtíží při šetření brání vývoji v této oblasti výzkumu.

Nepravidelné kontrolní testy jsou důležité, ale mají nevýhodu v tom, že nezdůrazňují důležitost jednotlivce. Na druhé straně návrhy jednotlivých případů mají značný potenciál adekvátně rozluštit mechanismy v práci a ve cvičení ve vztahu k mentálnímu zdraví.

Z klinické perspektivy by však na výsledky výzkumů mělo být pohlíženo na základě podpory dřívějších epidemiologických důkazů, které dokládají, že mentální onemocnění by mohlo být spojeno s nízkou fyzickou aktivitou, a ti, kteří jsou aktivnější, jsou méně náchylní k mentálním onemocněním.

Klíčová slova: cvičení, mentální zdraví, nepravidelné kontrolní testy, návrh jednotlivých případů.

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SELF-PERCEPTION OF NATIONAL TEAM COACHES IN VOLLEYBALL FOR THE DISABLED

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This study attempted to answer the basic questions concerning coaches of volleyball for the disabled: their self-perception, their perception of an ideal coach, and statistically significant differences among those two categories. The research sample consisted of 32 coaches of the national teams in volleyball for the disabled. Data was gathered during the European Championship in Sitting Volleyball for Women, the European Championship in Sitting Volleyball for Men and the World Cup in Standing Volleyball for Men, and were completed in 2003. The CSPL-TT94 List (Coach Self-Perception List, Tušak & Tušak, 1994) consists of 26 items about coaches' personal qualities important for successful coaching. A seven point scale from 0 to 6 was introduced to obtain coaches' level of self-perception and ideal coach characteristics. Coaches' self-perception shows us that the strong side of their personal characteristics important for coaching volleyball for the disabled lies in motivation, responsibility and self-confidence, while the lowest scores belong to anxiety, aggressiveness and individualism. An ideal coach is outstanding in motivation, responsibility and self-control with low scores in anxiety. In twenty out of twenty-six personal characteristics important for coaching volleyball for the disabled, we found statistically important differences. These findings have a particular relevance to those involved in coaching elite athletes in volleyball for the disabled. This paper also tries to promote better understanding of participation in sport for the disabled.

Keywords: Coaching, self-perception, competitive sport, volleyball for the disabled.

INTRODUCTION

The aims of sport encompass the same principles for disabled people as they do for the able-bodied. All over the globe, top athletes want to compete against the best athletes from other countries. At the international level, competitors are much more than just individuals having fun playing sports. As representatives of their nations, they carry extra responsibility for success. In team sports, teams are automatically associated with the country they represent (Beashel & Taylor, 1992). In volleyball for the disabled, most of the coaches, if not all, work on an amateur basis and are prepared to devote their own time to helping others to improve. The voluntary sector is by far the most developed, and without this sector it would be impossible to maintain sport in society.

Regardless of these facts all coaches need to understand their chosen sport thoroughly. They must be good at handling athletes with different personalities and abilities. It is very important that competitors have complete confidence in their coaches' ability to help them. Women have few senior coaching positions in volleyball for the disabled, which reflects the situation in sport and the coaching world in general, not only in sport for the disabled.

A top volleyball team requires a competent coach to train and develop players' abilities into perfection. Players should be coached according to their individual strengths and weaknesses including disability specifics. Coaching is not a mechanical process where a player goes to a coach who gives him or her the knowledge and the player takes it away with him or her and practices. Coaching involves the interaction of human beings with all the problems that this implies. From the information of coaches' self-evaluation, we could learn a great deal and help to make progress in various aspects of volleyball for the disabled and its protagonists – the players. A prominent coach of American football, Parcells, in 1995 pointed out some key factors which in his belief help coaches to be successful: integrity, flexibility, loyalty, confidence, accountability, preparedness, resourcefulness, self-discipline and patience.

Volleyball for the disabled and its typical forms, standing and sitting volleyball, is a type of sport characterised by close interactions, teamwork and deep cohesion. Co-operation exists in all parts of life and is an integral part of every success. The development of team cohesion is one of the most difficult tasks facing every coach. According to Tutko and Tosi (1976) before true team cohesion can exist, the following conditions should prevail: the players and the coach must appreciate the

value of each individual to the team, each team member must be willing to communicate and work towards understanding others, as well as helping others to understand him or her, the presence of the genuine feeling that the player is a member of the team and that his or her feelings are recognised, there should be a common belief in the team philosophy and the plans they must follow to achieve their goals, the need of every player to feel that he or she is being treated as fairly as possible and that he or she is being given an opportunity to display and develop his or her talents to the maximum. Top competitive sport is the most disputable part of the whole sport sphere regarding the disabled and their participation. The demonstration of power and abilities is common in sport generally and specifically in the sport for the disabled. When the intrinsic experience of sport is analysed, it is noted that the physically disabled also wish to prove themselves, they have an intense desire for achievement, they want to attract attention, etc. (Vute, 1992).

Self-awareness is the first step towards being in better control of your own game. The coach is generally seen as an expert who prepares other people for special situations. Kozel (1993) from the German Coaches Academy in Cologne pointed out that in the sports sector we associate the term coach with the voluntary sports instructor, the physical education teacher, and the professional coach in competitive and top competitive sport. The diversity of the tasks to be performed by a coach in his capacity as the central reference person of the athlete becomes clear if you consider the great number of influences which the athlete is exposed to. The coach, therefore, is not only responsible for his player in technical terms but, due to his pedagogical, psychological and organisational capabilities, must also be capable of influencing players' development. Studies and experience indicate that successful coaches show a greater ability to communicate, to interpret individual sensations, experiences, intuitions, a more effective leadership style, a good ability to take the other's standpoint. A coach's high potential is also determined by creativity, ability to improvise, supported by a strong theoretical, methodological and statistical knowledge base. Madella, Mano, Beccarini, Carbonaro and Cei (1994) and Tušak (1994) find characteristic elements which have determined successful coaches in basketball. The coaches themselves named the importance of professionalism, discipline, pedagogical knowledge, consistency, authority, equitability, justice, honesty and diligence, with the ability to communicate well, and also to be strict, inventive and persistent. A coach's philosophy has always had a strong effect on players, irrespective of the type of sport.

THE MAIN AIM AND GOALS

The main aim of this investigation was to obtain basic information about coaches' self-perception of those personal characteristics which determine the coaching of top level volleyball for the disabled. The paper analyses responses of national teams' coaches in order to:

- present coaches' backgrounds linked to volleyball for the disabled,
- identify personal characteristics that coaches possess and value as a strong side of their coaching volleyball for the disabled,
- identify personal characteristics with low scores on each coach's self-perception list,
- find out how coaches in volleyball for the disabled experience an ideal coach, according to their personal characteristics,
- find out which personal characteristics, important for coaching volleyball for the disabled, of a real as well as an ideal coach, show statistically significant differences.

The findings about coaches' self-perception will help to in the creation of educational programmes for coaches and teachers involved with sport for the disabled and particularly make volleyball for the disabled more efficient and credible.

METHODS

The research sample consisted of 32 coaches of national teams in volleyball for the disabled, which included sitting volleyball teams for men, sitting volleyball teams for women and standing volleyball teams for men. Among the respondents were 5 women coaches. The authors of the survey believed that this sample represented typical top level volleyball for the disabled and was suitable for research purposes. Data was gathered during the European Championship in Sitting Volleyball for Women, the European Championship in Sitting Volleyball for Men and the World Cup in Standing Volleyball for Men, and were completed in 2003. National teams' head coaches and assistant head coaches included in the survey were from the Netherlands (NED, 4 coaches), Finland (FIN, 3), Poland (POL, 2), Slovenia (SLO, 2), Germany (GER, 4), Croatia (CRO, 2), the Ukraine (UKR, 2), Hungary (HUN, 1), Russia (RUS, 1), Norway (NOR, 1), Bosnia and Hercegovina (BIH, 2), Latvia (LAT, 2), Lithuania (LIT, 1), Cambodia (CAM, 1), the United States of America (U.S.A., 1), Australia (AUS, 1), Slovakia (SVK, 1) and Greece (GRE, 1).

The CSPL-TT94 List (Coach Self-perception List, Tušak & Tušak, 1994) consists of 26 items about coaches' personal qualities important for successful coach-

ing. A seven point scale from 0 to 6 was introduced to obtain coaches' levels of self-perception and ideal personal characteristics. Number six on the scale was the strongest. Participants were asked to judge themselves as a coach and also choose what their ideal coach would be like. Evaluated variables covered the following characteristics:
1) punctuality, 2) discipline, 3) self-control, 4) creativity, 5) motivation, 6) concentration, 7) self-confidence, 8) flexibility, 9) democracy, 10) individualism, 11) efficiency, 12) love of order, 13) self-improvement, 14) independence, 15) tendency to dominate, 16) Aability to admit mistakes, 17) consistency, 18) systematic thinking, 19) self-trust, 20) anxiety, 21) quietness, 22) self-respect, 23) emotional stability, 24) Aaggressiveness, 25) authority, 26) responsibility.

Descriptive statistics were conducted to examine aspects of coaches' backgrounds important for their involvement in volleyball for the disabled: gender, age groups, coaching experience with national teams, professional background, greatest coaching success, and previous experiences with coaching able-bodied teams. Five female respondents were also considered as coaches. Mean scores and standard deviations for each item on each coach's self-perception list were calculated for the total sample of coaches. The T-test procedure was used to determine differences in personal characteristics between the questioned coaches for volleyball for the disabled and an ideal coach. Statistically significant differences were reported according to mean rank scores. For statistical interpretation we used the SPSS 9.0 for Windows programme.

RESULTS AND DISCUSSION

Coaches' backgrounds in volleyball for the disabled

A short overview shows us that the total of 32 participating coaches come from 18 countries, which are all members of the World Organisation of Volleyball for the Disabled. This organisation is, among others, responsible for running international championships. Countries like Germany, the Netherlands, Finland, Poland and Slovenia have national teams in various forms of volleyball for the disabled. Sitting volleyball for men, sitting volleyball for women and standing volleyball for men are considered to be volleyball for the disabled. The gender distribution of coaches of national teams (15.6% women, 84.4% men) help us identify the fact that men predominate in elite volleyball for the disabled. With sitting volleyball for women entering the international scene, which includes a first appearance at the Athens 2004 paralympic tournament, we may get new opportunities for female coaches. One major problem for female coaches is that it is seen from the male point of view. Successful women coaches are likely to be those who adopt male styles of coaching. There are some indications that a more democratic style, which is favoured by many women, produces equally good results, if such a style is not rejected. Age groups of coaches included in the research project were: up to 25 years (1 coach, 3.1%), 26–35 years (9 coaches, 28.1%), 36–45 years (11 coaches, 34.4%), 46–55 years (5 coaches, 15.6%) and 56 or more years (6 coaches, 18.8%). Most coaches belong to the 26–35 years age group and the 36–45 years age group, which represents in total 62.5% of all coaches. The number of coaches in the last age group confirms that age is not a serious obstacle for coaching top volleyball for the disabled teams. In a competitive sport, a successful coach is determined primarily by results, regardless of his or her age. Previous coaching experiences with volleyball for the disabled national teams were divided into six categories: up to 1 year experience (4 coaches, 12.5%), 1–2 years (10 coaches, 31.3%), 3–4 years (6 coaches, 18.8%), 5–6 years (2 coaches, 6.3%), 7–8 years (2 coaches, 6.3%) and more than 9 years of experiences (8 coaches, 25%). The possibility of gaining experience in coaching national teams in volleyball for the disabled depends on a number of circumstances. Sport for the disabled has increased in popularity in the last decade, particularly with its positioning within the regular Olympic movement. Coaches are challenged by an attractive sport option and by the possibility of fullfilling their own personal ambitions as well. Nomination for the National team's head coach depends also on the acceptance of conditions between National Federations responsible for volleyball for the disabled and candidates for the head coach position who are, in principle, volunteers.

Coaches' professional backgrounds were designated within three groups: physical education teachers (17 coaches, 53.1%), other teaching professions (2 coaches, 6.3%) and all other professions (13 coaches, 40.6%). Physical education teachers dominate as a professional group among coaches in elite volleyball for the disabled. The respected John Wooden, former UCLA basketball coach (Wooden, 1988), expressed his view on the teaching – coaching subject: "When I was coaching I always considered myself a teacher. Teachers tend to follow the laws of learning better than coaches who do not have any teaching background. A coach is nothing more than a teacher. I used to encourage anyone who wanted to coach to get a degree in teaching so they could apply those principles to athletics."

As coaches' greatest success, we recognise medals won in three major sport events: paralympic games (6 coaches, 18.8%), world championships (4 coaches, 12.5%) and continental championships (6 coaches, 18.8%), in the fourth category were coaches without

any of these medals (16 coaches, 50.0%). Half of the coaches of national teams possess medals from some of those major competitions, while the other half of them are still looking for the opportunity to win them.

The first step for players and their coaches is to qualify for such an event. Qualification for major events, where paralympic qualifications are the most selective and demanding, end many athletes' and coaches' dreams of glory. Positive answers about coaching experiences with able-bodied teams come from 23 coaches (71.9%), while 9 of them (28.1%) do not have such experiences. Experiences with coaching able-bodied volleyball teams by many of today's coaches of volleyball for the disabled indicate where they have learned and mastered their skills. Volleyball for the disabled enjoys the benefits of such coaches' experiences. Additional knowledge about disability specifics and sport adaptations is necessary for safe and successful coaching of volleyball for the disabled.

TABLE 1
Coaches' self-perception and their perception of an ideal coach (a = real coach, b = ideal coach)

Item	Personal characteristics	Minimum	Maximum	Mean	Std. deviation
1a	Punctuality	3	6	4.34	.827
1b		3	6	5.34	.787
2a	Discipline	2	6	4.56	.982
2b		3	6	5.37	.871
3a	Self-control	3	6	4.53	.983
3b		4	6	5.75	.508
4a	Creativity	2	6	4.41	1.214
4b		4	6	5.62	.751
5a	Motivation	3	6	5.13	.942
5b		5	6	5.78	.420
6a	Concentration	3	6	4.53	.983
6b		4	6	5.69	.535
7a	Self-confidence	3	6	4.91	.893
7b		4	6	5.59	.560
8a	Flexibility	3	6	4.69	1.091
8b		4	6	5.53	.671
9a	Democracy	3	6	4.56	1.076
9b		2	6	4.78	1.408
10a	Individualism	1	6	3.87	1.362
10b		1	6	4.47	1.414
11a	Efficiency	2	6	4.56	1.105
11b		3	6	5.31	.780
12a	Love of order	1	6	4.38	1.408
12b		1	6	4.94	1.343
13a	Self-improvement	1	6	4.34	1.153
13b		1	6	5.16	1.273
14a	Independence	2	6	4.66	1.125
14b		3	6	5.13	1.040
15a	Tendency to dominate	2	6	4.13	1.129
15b		2	6	4.84	1.139
16a	Ability to admit to having made mistakes	2	6	4.63	1.129
16b		2	6	5.50	.880
17a	Consistency	2	6	4.53	1.164
17b		3	6	5.63	.751
18a	Systematic thinking	3	6	4.50	.916
18b		2	6	5.47	.842
19a	Self-trust	3	6	4.75	1.107
19b		2	6	5.53	.842

20a	Anxiety	1	6	3.22	1.755
20b		0	6	2.84	1.919
21a	Quietness	2	6	4.00	1.295
21b		2	6	4.87	1.289
22a	Self-respect	3	6	4.91	.928
22b		3	6	5.59	.756
23a	Emotional stability	2	6	4.53	1.107
23b		2	6	5.34	.937
24a	Aggressiveness	0	6	3.22	1.385
24b		0	6	3.34	1.619
25a	Authority	1	6	4.28	1.301
25b		1	6	5.19	1.378
26a	Responsibility	3	6	5.12	.976
26b		4	6	5.75	.508

Coaches' self-perceptions shows us that the strong side of their personal characteristics important for coaching volleyball for the disabled, expressed by the highest mean scores, lies in motivation (mean score 5.13), responsibility (5.13) and self-confidence (4.91). The lowest mean scores in coaches' self-perceptions belong to the personal characteristic of anxiety (3.22), aggressiveness (3.22) and individualism (3.88). Items with the highest mean scores, according to coaches' perceptions of an ideal coach, were identified as motivation (5.78), responsibility (5.75) and self-control (5.75). The ideal coach gets the lowest scores in anxiety (2.84), aggressiveness (3.34) and individualism (4.47). Differences were always expressed in the direction towards the higher value of an ideal coach. The reverse situation was only noted in the anxiety item. Practical experience show us that successful coaches are generally persons lacking fear and who have an expressed lower level of anxiety.

Motivation, responsibility and self-confidence show the highest mean scores of personal characteristics evaluated by coaches. Maximising performance of the many specific skills of volleyball for the disabled is the unique role of the coach. To do so, motivational efforts are essential and, according to the questioned coaches, they possess such capabilities. Group dynamics has been proven as a very efficient tool in the hands of an experienced and motivated coach. A motivated coach provides better chances for success for both athletes and coaches. Responsibility seems to grow together with the coach in the position of the national team coach. Confidence is built through success in competitions and in their recognition. Coaches' confidence is enhanced when they know they are performing well and this depends on players' efforts and accomplishments. Confidence is a belief in one's own ability, and means accepting challenges that test limits. All three highly scored characteristics play an important role in each coach's performance and have direct influence on players' achievements. They also express expectations that an ideal coach should be very strong in motivation as well as a highly responsible person and be able to control himself in complex top sport conditions. Existing qualities should be upgraded in ideal circumstances into perfection. Fear and anxiety get low scores as a result of the fact that the mentioned personal characteristics do not determine successful coaching. The lack of fear and anxiety in a coach brings his or her team more chances to win the game or tournament, but also risks. Anxiety can hamper development and affect the coach's overall attitude towards the game, and make players stop trying. A posture of aggressiveness shows us that a winning at all costs philosophy, in volleyball for the disabled, is not yet predominant. Individualism is considered to be less exposed, but strong enough that we should be aware of its presence in volleyball for the disabled.

Although these personal characteristics are important contributors to coaching success, other aspects of coach and player relations must also be taken into consideration. Coaches participating in the actual research expressed that self-perception and the perception of an ideal coach are very much on the same perception line with expected differences favouring an ideal coach. Results indicated that the coaches of national teams in volleyball for the disabled fully believed in their competence. The way that coaches see their own qualities and expectations in ideal circumstances, there is no need for reorganisation aspirations of their personal characteristics, just the need to be upgraded toward the imagined ideal level.

Statistically important differences between a real and an ideal coach

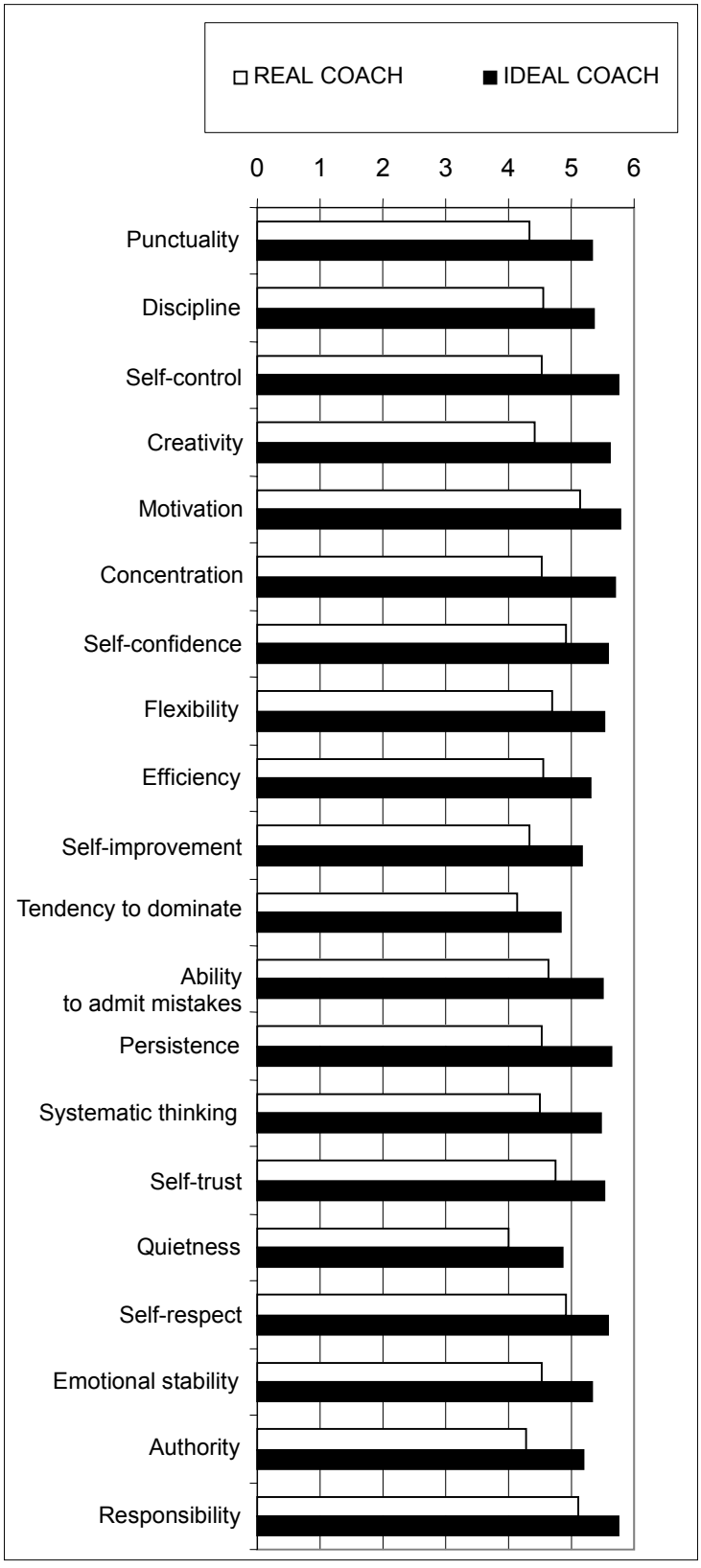
With the help of the T-test procedure, we identified statistically important differences between marks of coaches' self-perception and marks of their perception of an ideal coach. A higher value of the mean scores

also determine a higher level of the expressed personal characteristics. In twenty out of twenty-six personal characteristics important for coaching volleyball for the disabled, we found statistically important differences (on the significant level of 0.05). Those personal characteristics were: punctuality, discipline, self-control, creativity, motivation, concentration, self-confidence, flexibility, efficiency, self-improvement, tendency to dominate, ability to admit to mistakes, persistence, systematic thinking, self-trust, quietness, self-respect, emotional stability, authority and responsibility.

TABLE 2
Statistically significant differences between a real and an ideal coach (a = real coach, b = ideal coach)

Paired Differences									
		95% Confidence interval of the difference							
Pair	Personal characteristics	Mean	Std. deviation	Std. error mean	Lower	Upper	T- value	Df	Sig. (2-tailed)
Pair 1	1a–1b	–1.00	.842	.149	–1.30	–.70	–6.715	31	.000
Pair 2	2a–2b	–.81	.821	.145	–1.11	–.52	–5.601	31	.000
Pair 3	3a–3b	–1.22	1.008	.178	–1.58	–.86	–6.843	31	.000
Pair 4	4a–4b	–1.22	1.157	.204	–1.64	–.80	–5.961	31	.000
Pair 5	5a–5b	–.66	.865	.153	–.97	–.34	–4.289	31	.000
Pair 6	6a–6b	–1.16	.954	.169	–1.50	–.81	–6.855	31	.000
Pair 7	7a–7b	–.69	.780	.138	–.97	–.41	–4.984	31	.000
Pair 8	8a–8b	–.84	.987	.175	–1.20	–.49	–4.834	31	.000
Pair 9	9a–9b	–.22	1.039	.184	–.59	.16	–1.191	31	.243
Pair 10	10a–10b	–.59	1.214	.215	–1.03	–.16	–2.766	31	.009
Pair 11	11a–11b	–.75	1.016	.180	–1.12	–.38	–4.176	31	.000
Pair 12	12a–12b	–.56	1.366	.242	–1.06	–.07	–2.329	31	.027
Pair 13	13a–13b	–.81	1.061	.188	–1.19	–.43	–4.333	31	.000
Pair 14	14a–14b	–.47	1.164	.206	–.89	–.05	–2.279	31	.030
Pair 15	15a–15b	–.72	1.114	.197	–1.12	–.32	–3.650	31	.001
Pair 16	16a–16b	–.88	1.008	.178	–1.24	–.51	–4.910	31	.000
Pair 17	17a–17b	–1.09	.995	.176	–1.45	–.73	–6.215	31	.000
Pair 18	18a–18b	–.97	1.332	.235	–1.45	–.49	–4.115	31	.000
Pair 19	19a–19b	–.78	1.039	.184	–1.16	–.41	–4.253	31	.000
Pair 20	20a–20b	.38	1.289	.228	–.09	.84	1.646	31	.110
Pair 21	21a–21b	–.88	1.100	.194	–1.27	–.48	–4.500	31	.000
Pair 22	22a–22b	–.69	.780	.138	–.97	–.41	–4.984	31	.000
Pair 23	23a–23b	–.81	1.120	.198	–1.22	–.41	–4.104	31	.000
Pair 24	24a–24b	–.13	1.362	.241	–.62	.37	–.519	31	.607
Pair 25	25a–25b	–.91	1.118	.198	–1.31	–.50	–4.587	31	.000
Pair 26	26a–26b	–.63	.793	.140	–.91	–.34	–4.458	31	.000

TABLE 3
Graphic presentation of statistically significant differences of coaches' self-perception and perception of an ideal coach



Mean scores:

- punctuality: coach (4.34) – ideal coach (5.34),
- discipline: coach (4.56) – ideal coach (5.37),
- self-control: coach (4.53) – ideal coach (5.75),
- creativity: coach (4.41) – ideal coach (5.62),
- motivation: coach (5.13) – ideal coach (5.78),
- concentration: coach (4.53) – ideal coach (5.69),
- self-confidence: coach (4.91) – ideal coach (5.59),
- flexibility: coach (4.69) – ideal coach (5.53),
- efficiency: coach (4.56) – ideal coach (5.31),
- self-improvement: coach (4.34) – ideal coach (5.16),
- tendency to dominate: coach (4.13) – ideal coach (4.84),
- ability to admit mistakes: coach (4.63) – ideal coach (5.50),
- persistence: coach (4.53) – ideal coach (5.63),
- systematic thinking: coach (4.50) – ideal coach (5.47),
- self-trust: coach (4.75) – ideal coach (5.53),
- quietness: coach (4.00) – ideal coach (4.87),
- self-respect: coach (4.91) – ideal coach (5.59),
- emotional stability: coach (4.53) – ideal coach (5.34),
- authority: coach (4.28) – ideal coach (5.19),
- responsibility: coach (5.12) – ideal coach (5.75).

A coach's philosophy will have a strong effect on players of volleyball for the disabled. Sport gives participants an opportunity to learn, to co-operate, to become more independent, etc. Pedagogical and psychological aspects of coaching should be part of any systematic training programme. A healthy philosophy of winning is, for many, the most important factor to look for in a coach for disabled athletes. Top volleyball for the disabled demands qualified and experienced coaches to be ready to deal with all the complexity of disability specifics. The safety of athletes should always be a priority. Enthusiastic leaders generate an atmosphere which motivates players to train harder and play better. Communication skills are known to increase coaching effectiveness, especially if coaches are prepared to listen to their athletes. Ruling with authority does not necessarily assure a team's success and is not very popular among the top level players. A coach who shows self-control is likely to be more effective, while a coach who loses his temper and screams at players and officials also loses his or her own authority. An inside view into coaches' self-perception and their perception of an ideal coach enable us to better understand the coaching process of volleyball for the disabled. It could also inspire coaches to look more closely at themselves and their coaching of volleyball for the disabled.

CONCLUSION

This study attempted to answer the basic questions concerning coaches of volleyball for the disabled: their self-perception, their perception of an ideal coach, and statistically significant differences among the mentioned categories. The backgrounds of coaches explain some details of their patterns of involvement with volleyball for the disabled. Gender distribution of coaches of national teams (15.6% women, 84.4% men) identify that men predominate in elite volleyball for the disabled. Most coaches belong to the 26–35 years age group and the 36–45 years age group, which means in total 62.5% of all coaches. In competitive sport, a successful coach is determined primarily by results, irrespective of his or her age. A nomination for National team head coach depends on various conditions, where coaches are, in principle, volunteers. Physical education teachers dominate as a professional group among coaches in elite volleyball for the disabled. Half of the coaches of National teams possess medals from major competitions, while the other half of them still are looking for the opportunity to win paralympic, world or continental championship medals. Experiences with coaching able-bodied volleyball teams by many of today coaches of volleyball for the disabled indicate their coaching background. Coaches' self-perception shows us that the strong side of their personal characteristics important for coaching volleyball for the disabled lies in motivation (mean score 5.13), responsibility (5.13) and self-confidence (4.91), while the lowest scores belong to anxiety (3.22), aggressiveness (3.22) and individualism (3.88). An ideal coach is outstanding in motivation (5.78), responsibility (5.75) and self-control (5.75) with low scores in anxiety (2.84). Practical experience indicates that successful coaches are generally persons lacking fear who have an expressed lower level of anxiety. In twenty out of twenty-six personal characteristics important for coaching volleyball for the disabled, we found statistically important differences (significant level = 0.05): punctuality, discipline, self-control, creativity, motivation, concentration, self-confidence, flexibility, efficiency, self-improvement, tendency to dominate, ability to admit mistakes, persistence, systematic thinking, self-trust, quietness, self-respect, emotional stability, authority and responsibility.

Coaches in volleyball for the disabled do a fine job and have the well-being of their disabled athletes as their primary goal. Some programmes of volleyball for the disabled are possible only because of devoted volunteers in the position of coaches. Although many do not have optimal conditions for their coaching, they compensate it with efforts to do the best for volleyball for the disabled teams. To provide extensive feedback to coaches on their interactions with situations arising in connection with volleyball for the disabled, based on data collected during top level competitions, we intend to encourage

coaches to learn more about themselves and their coaching performance. Coaches' self-evaluation results could provide useful guidance for their self-teaching corrections. Athletes with disabilities, including disabled volleyball players, will benefit from better qualified coaches. The World Organisation of Volleyball for the Disabled intends to put more effort into encouraging national volleyball for the disabled organisations and other interested parties to join coaching education programmes. Even top level coaches, through refresher courses, can become more confident and more enthusiastic in their training seasons. The present evaluation is a small step towards better understanding of coaches and the coaching process of volleyball for the disabled.

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SEBEPERCEPCE TRENÉRŮ NÁRODNÍHO VOLEJBALOVÉHO TÝMU POSTIŽENÝCH

(Souhrn anglického textu)

Příspěvek se pokusí odpovědět na základní otázky týkající se trenérů volejbalu pro postižené: jejich sebepercepce, jejich vnímání ideálního trenéra, a statisticky zachytit významnost rozdílů mezi těmito dvěma kategoriemi.

Výzkumný vzorek se skládal ze 32 trenérů národních volejbalových týmů tělesně postižených. Data byla shromážděna během Mistrovství Evropy žen ve volejbalu vsedě, Mistrovství Evropy mužů ve volejbalu vsedě a Světového poháru mužů ve volejbalu vestoje. Sběr dat byl dokončen v roce 2003. Inventář CSPL-TT94 (Seznam sebepercepce trenérů) se skládá z 26 položek, týkajících se osobních kvalit trenérů, které jsou důležité pro úspěšné trénování týmů. Sedmibodová stupnice od 0 do 6 umožňuje získat informace o úrovni sebeprecepce trenérů a jejich ideální charakteristiky. Sebepercepce trenérů ukazuje, že silná stránka jejich osobních charakteristik důležitých pro trénování volejbalu pro postižené je v jejich motivaci, zodpovědnosti a sebedůvěře, zatímco charakteristiky jako úzkost, starost, agresivita a individualismus měly nižší bodové hodnocení. Ideální trenér je vynikající v motivaci, zodpovědnosti a sebeovládání s malou úzkostí.

Mezi 20 z 26 osobních charakteristik důležitých pro trénování volejbalu pro postižené jsme nalezli statisticky významné rozdíly.

Prezentované poznatky jsou významné pro ty, kteří jsou zapojeni v tréninku vrcholových volejbalistů s postižením a pokouší se vytvořit lepší klima sportujícím osobám s postižením.

Klíčová slova: trénování, sebepercepce, soutěživý sport, volejbal pro postižené.

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INSTRUCTIONS FOR MANUSCRIPT

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

General instructions

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

The text is to be presented in MS Word editor 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.

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

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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.

Topics
- Somatic and motoric problems associated with physical activities
- Optimization of the load and minimization of health risks of physical activities
- Current new trends in diagnosis and therapy of sport injuries
- Biomechanical and physiotherapeutical aspects of the human movement system
- Social, philosophical and psychological determinants of life style
- Quality of life and sport activities of persons with special needs
- Physical activities in school
- Women and sport
- Outdoor, tourism and new age activities
- Management and marketing of sport and physical activities
- Research methods in physical activities
- Spectral analysis of heart rate variability – health and movement

Conference venue
Palacký University, Faculty of Physical Culture
tř. Míru 115, 771 11 Olomouc, Czech Republic

Date
November 23–25, 2005

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

Forms of presentation
keynote lecture, oral, poster, workshop

Conference fee
150 EUR, 60 EUR (student, Ph.D. student)
The conference fee covers all academic activities, refreshments during the conference, proceedings and social programme.

Important dates
May 2005, Application and conference fee
July 2005, Deadline for papers submission
September 2005, Second Announcement

Contact person
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František Vaverka
Chairman of the scientific committee

Miroslav Janura
Chairman of the organizing committee