JUMP ERGOMETER IN SPORT PERFORMANCE TESTING

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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)

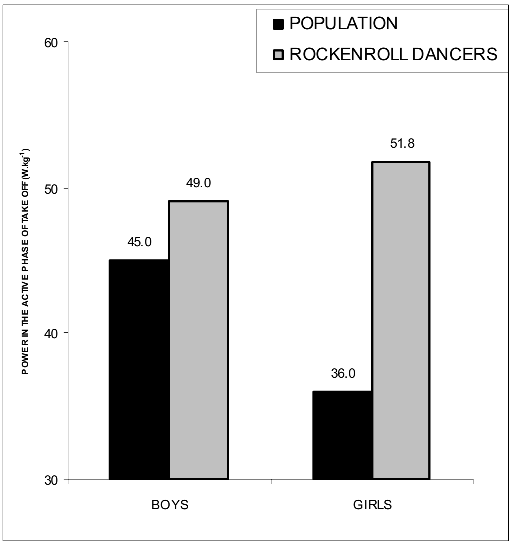
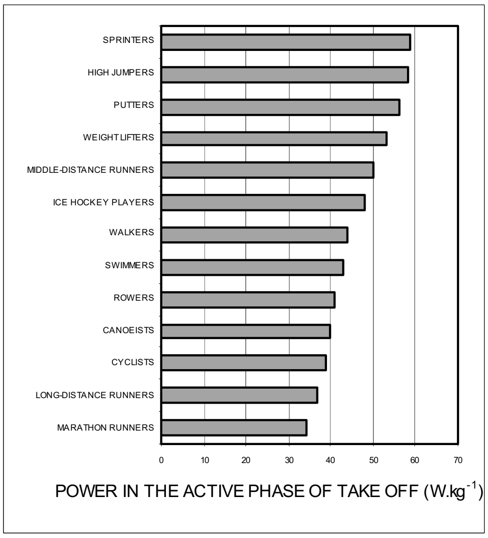


Fig. 4
Power in the active phase of take off in athletes of different specializations (Hamar, 1991)



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)

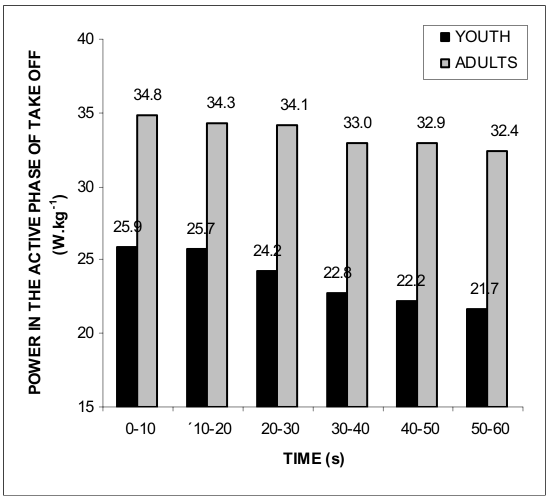


Fig. 6
Power in the active phase of the take off in a 90-s test on the jump ergometer (rock and roll dancers, n = 18)

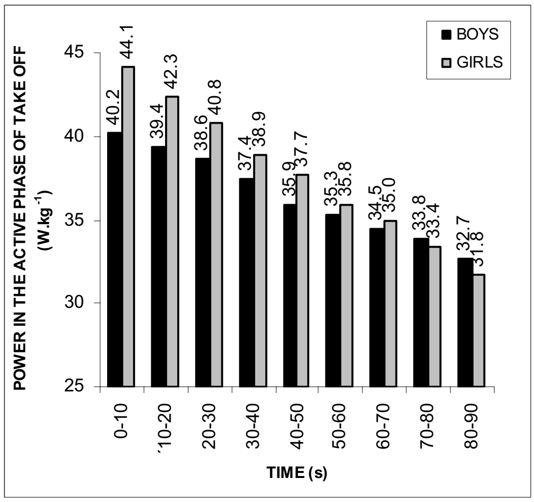
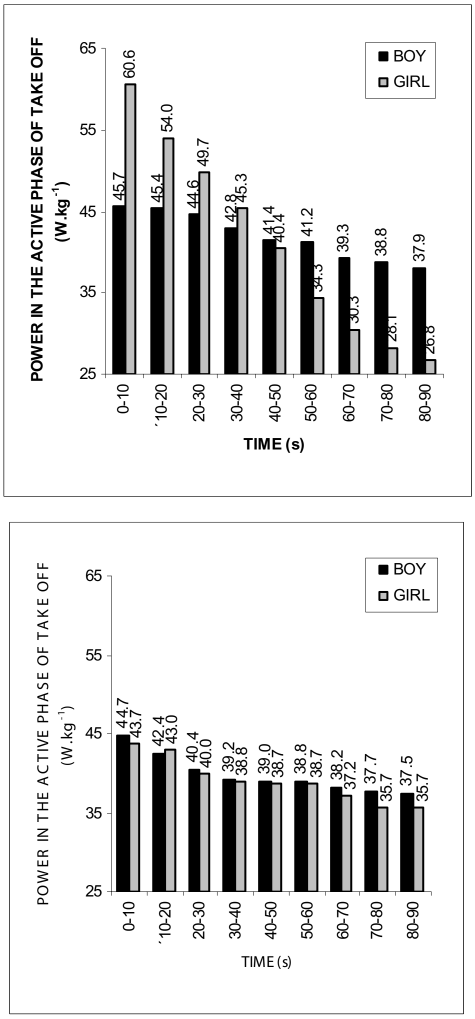


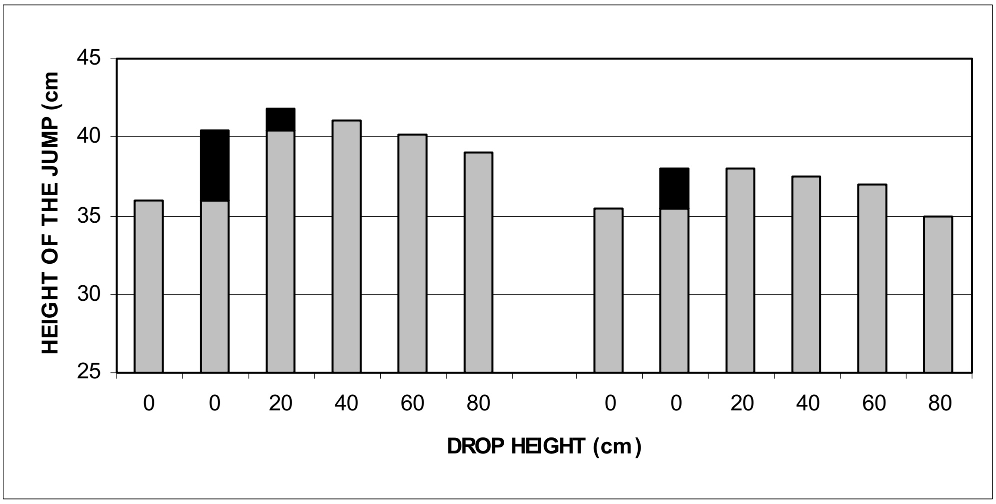
Fig. 7, 8
Power in the active phase of the take off during a 90-s test of repeated jumps in rock and roll dancers (an example of two couples)



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

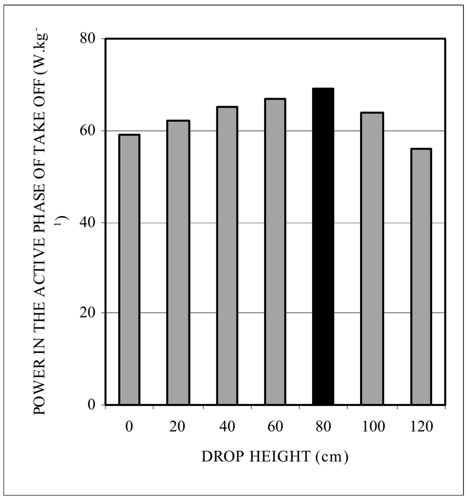


Fig. 11
Height of the drop jump in athletes of different specializations

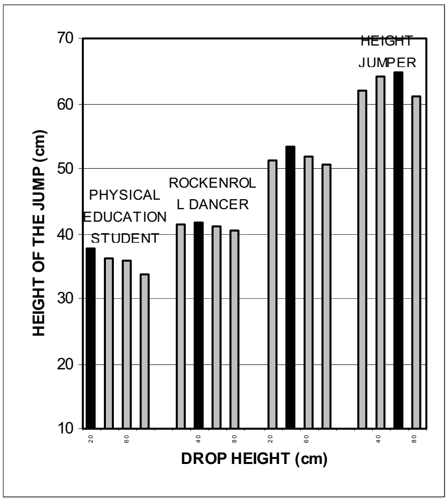
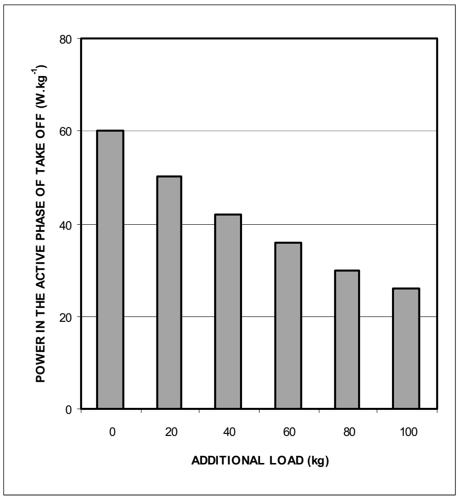


Fig. 12
Power decrease with increased additional load (a barbell across the shoulders)



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)

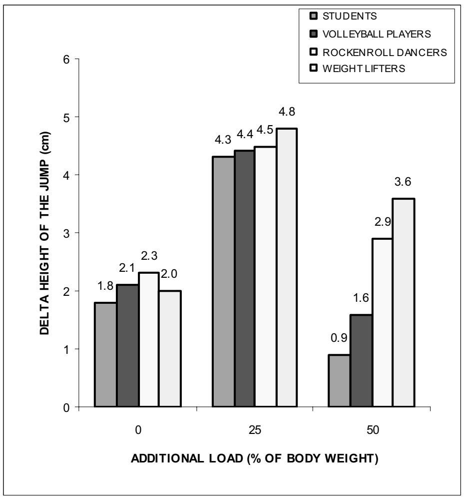
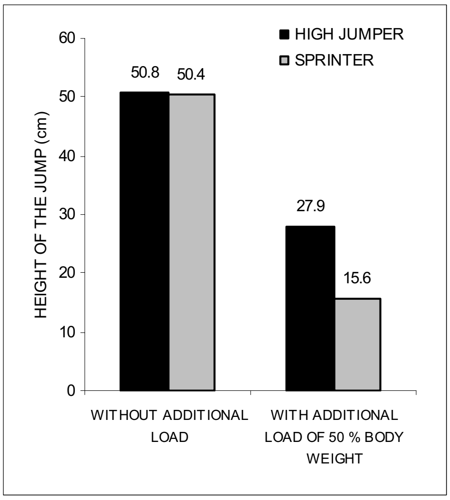
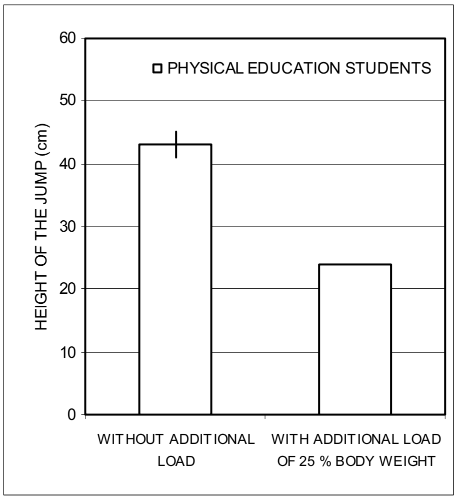


Fig. 14, 15
Squat and countermovement drop jumps without and with an additional load (high jumper and sprinter and 56 physical education students, respectively)

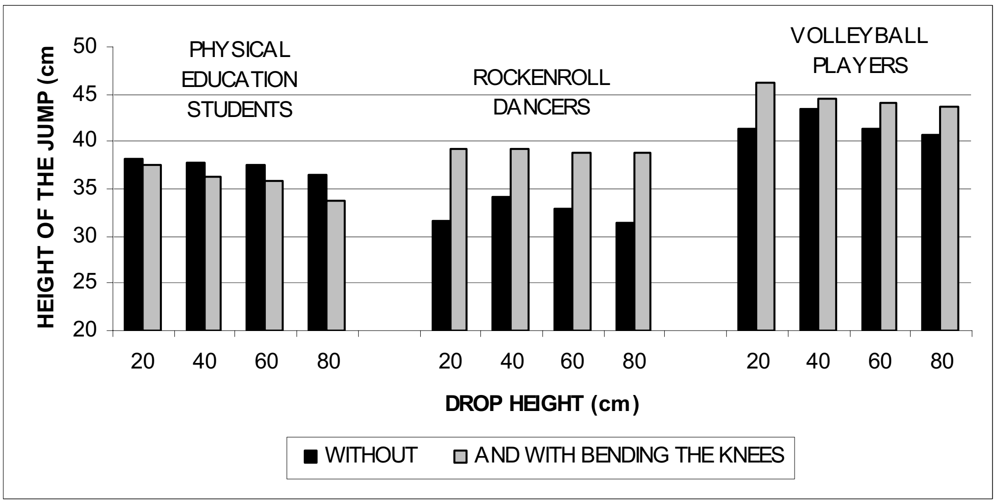




Evaluation of sport specific performance

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)



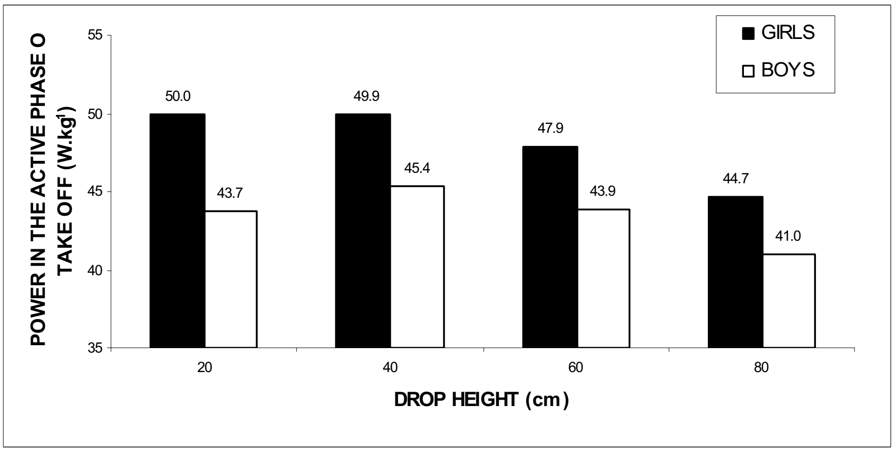
In particular, in rock and roll, it is known from the biomechanical analysis of jumps that girls tend to perform bounces from straight legs while boys jump from bent knees. Tests has been found to reveal this different character of jumping between male and female dancers (Zemková et al., 2001).

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.

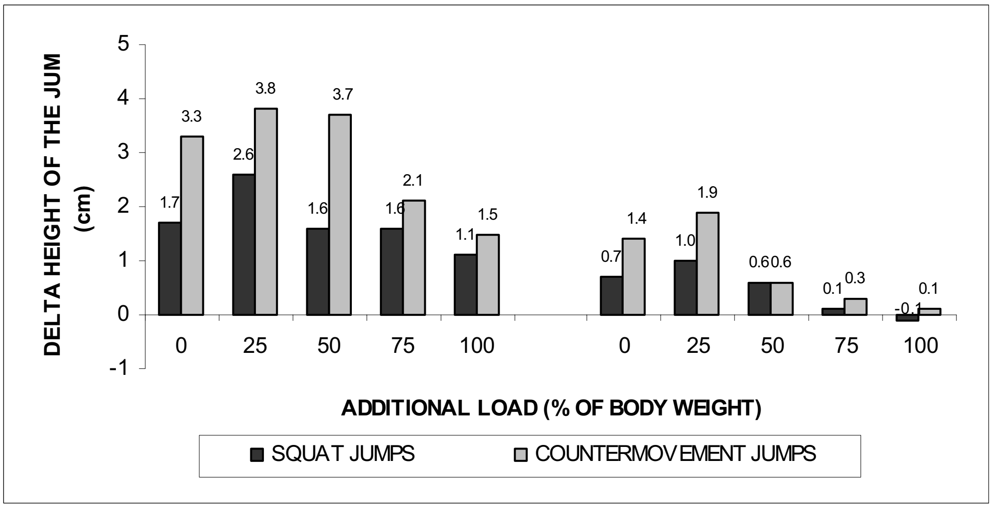


Fig. 19
Height of drop jumps from heights of 20, 40, 60, and 80 cm performed without and with bending the knees prior to and after one year of training in volleyball players (n = 8)

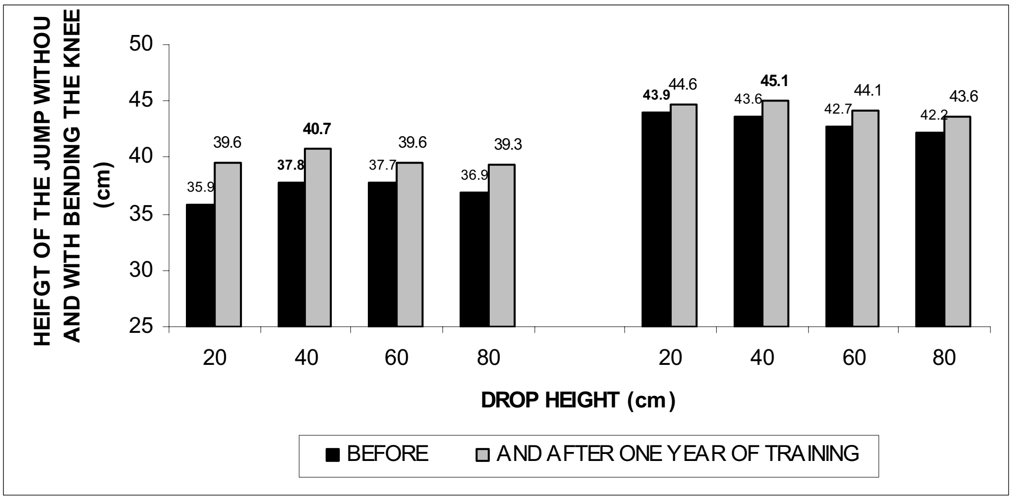
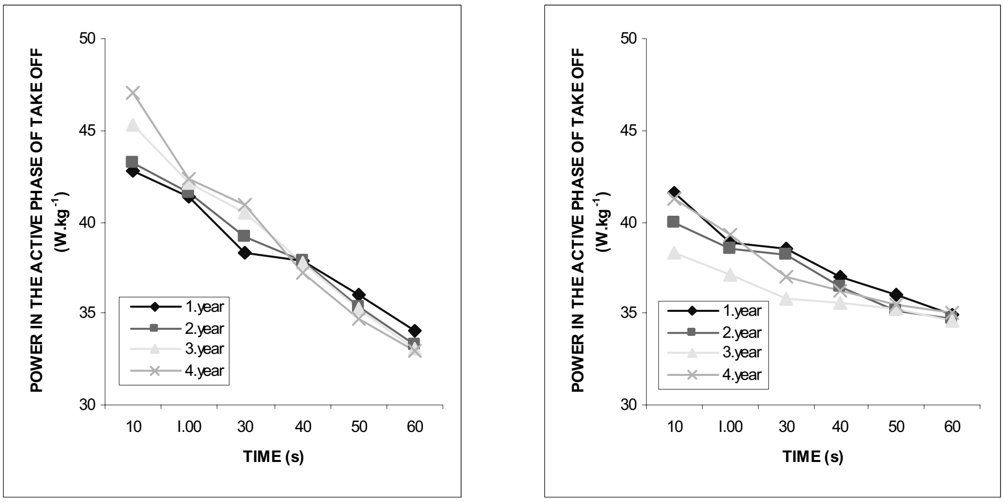


Fig. 20, 21
Power in the active phase of the take off in a 60-second test on the jump ergometer during four years of training in female and male rock and roll dancers (n = 10) (Dzurenková et al., 2001; Zemková et al., 2003)



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 různých 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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Faculty of Physical Education and Sports, Comenius University, 1994 Master's Degree (Physical Education and Sports), 1999 Philosophiae Doctor (Sports Kinantropology), since 1997 work at department of Sports Medicine, Institute of Sport Sciences, Faculty of Physical Education and Sports, Comenius University, Assistant Professor, Functional assessment of athletes and teaching university courses.

Scientific orientation

Her research activities are focused on elaboration of methods and sport specific norms for the evaluation of agility, anaerobic capabilities, explosive power and postural sway.

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