The Method for Testing the Dynamic of Take-off

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INTRODUCTION

Among various sport branches there are such in which the take-off efficiency, and consequently, performing of the exercise depends upon technique and muscles ability to release the maximal energy in a short time. Long and high jumps, acrobatic jumps, ski jumps, volley-ball and basket-ball jumps should be included among the above described branches. In these sports take-offs with one or both legs are employed. Certain elements which may be treated as belonging to technique have some influence upon the efficiency of the energy released during a take-off. In the case of the features in question they are: a degree and velocity of flexion of legs' joints before their extension. On the basis of their research, Murray et al. (1970) and Scudder (1980) stated that the optimum angle for achieving the maximal knee extension strength is the angle of 120° (in isokinetic conditions). Lindahl et al. (1969) obtained similar results in isometric conditions. Osterning et al. (1982) proved that the maximal strength can be reached at the angle form 100° to 110°. Secher et al. (1976) were examining the maximal strength of the leg extensors during a take-off with one leg and with both legs. They noted obvious differences between the strength measures in both tests, which must be connected with the take-off efficiency. The above mentioned question was dealt with by Van Soest et al. (1985). While examining take-off with one and both legs of well-trained volley-ball players they obtained jumps' results: 0.31 m and 0.54 m respectively. In this paper we intend to test the take-off with one leg and the take-off with both legs employing a pendulum which makes it possible to eliminate gravity force which normally influences a take-off. Take-off tested in this way analysed on the background of the static strength of legs.

MATERIAL

Thirteen subjects have been examined: 10 students of physical education and 3 sportsmen, a volley-ball player, a basket-ball player, and decathlonist (see Table 1).

TABLE 1

The characteristics of the examined subjects

Subjects	Sport level	Body height (cm)	Body weight (kg)
Students (n=10)		172 ± 5,56	64.8 ± 3.19
Volleyballer	1st division	192	89
Basketballer	1st division	204	93
Decathlonist	8105 points	180	88

METHOD

The examination consisted of two tests and included the measurements of right and left leg extensors' strength, one-legged and two-legged, and the measurement of the take-off from the wall with one and both legs in a recumbent position on the pendulum in two versions: a) from the arrested position, that is semi-dynamic take-off (SDT-0) which may be equivalent to squatting jump (SJ) and b) from the swing of the pendulum, that is dynamic take-off (DT-0) which corresponds with (CMJ) counter movement jump.

In the first test an apparatus consisting of a foot-dynamometer attached to a movable chair was used. The examinations were carried out in a sitting position, the knee angle being 120° and the hip-joint angle being 60°, assuming the maximal extension in these joints to be 180° (Figure 1).

In the second test the pendulum (Bober et al., 1980) was employed (Figure 2a), which helped determine muscles' ability to release the take-off energy from the arrested position SDT-0 (Figure 2b) and from the moving position DT-0 (Figure 2c). In the first position the angle in knee joints was 120°, in the second position the degree of bending was optional and was deeper as a rule (< 120°).

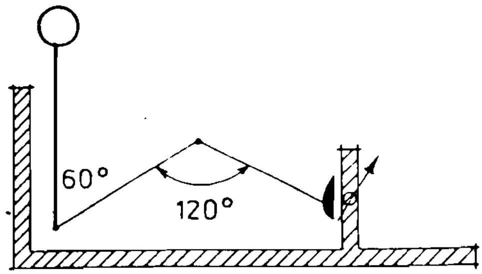

Fig. 1. Position for measuring muscle strength of leg extensors (one or two legged).

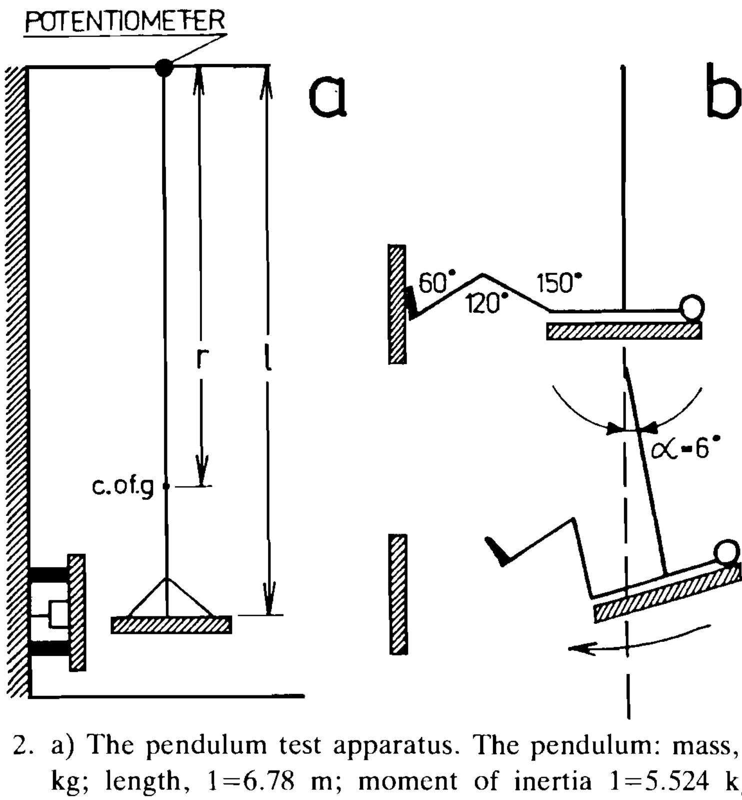

Fig. 2. a) The pendulum test apparatus. The pendulum: mass, m=152 kg; length, 1=6.78 m; moment of inertia 1=5.524 kgm^2; b) take-off from the arrested position (semi-dynamic SDT-0) knee angle=120°; c) starting position before take-off in dynamic test (DT-0).

In the course of the measurements the examined person was laid down in a moulded bed, so that even a very strong take-off wouldn't result in a displacement of the body in relation to the bed. The support plate was pulled close to the feet (the examined person had his legs extended), the angular displacement of the pendulum sensor was zeroed. The arm of the pendulum together with the subject were deflected always by the angle of 6° and then released freely (DT-0) moning in the direction of the plate. The examined subject took-off with the maximal force. In the case of the semi-dynamic take-off test the support plate was pulled close to the feet. The legs were bent, the knee angle being 120°. Then the examined person took-off the plate.

RESULTS

Basic strength and take-off measurements were described for the group of students separately. They are included in Table 2.

TABLE 2

Strength of lower extremities (F) and the semi-dynamic (SDT-0) and dynamic (DT-0) take-off results. N = 10.

	Units	Two-legged		One-legged			
				Left		Right	
		$\overline{X}$	SD	$\overline{X}$	SD	$\overline{X}$	SD
F	N	1880	558	1129	449	1090	335
SDT-0	m	1.17	0.38	1.14	0.34	1.12	0.45
DT-0	m	1.32	0.20	1.30	0.21	1.29	0.30

The dynamic take-off results (DT-0) are better than those of the semi-dynamic take-off (SDT-0) by about 9%. The DT-0 results are three times better than average vertical take-off results, i.e. those performed against gravitation force. In the former case the difference is due to the legs extensors elastic energy being taken advantage of (Bosco, 1982), in the latter case it is caused by reduced resistance (gravity).

Adopting average results in the group of students as 100% we have compared three examined sportsmen to them (Figure 3). The sportsmen are stronger than the students by 50-100%. The difference between take-off results amounts to 3-10%. The basket-baller has no advantage over the students as far as take-off results are concerned. The decathlonist's results are better than those of the volley-baller and basket-baller.

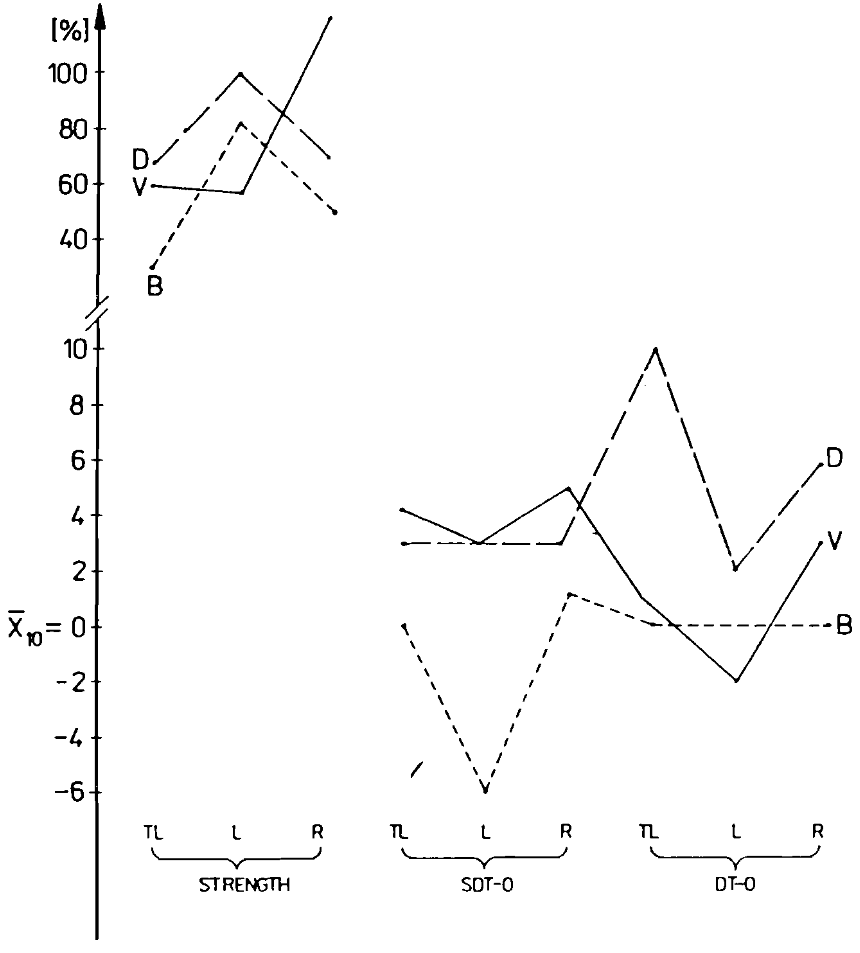

Fig. 3. Differences in percentages between the average students group (100%) results and those of the volley-baller (V), the basket-baller (B) and the decathlonist (D). The results of legs' strength, semi-dynamic take-off (SDT-0) and dynamic take-off (DT-0). All results are for two-legged test (TL) and one-legged that is left (L) and right (R).

The differences between the results of the two-legged take-off and one-legged are quite interesting. The results of all the examined persons were taken into consideration (N-13). On the assumption that half of the strength value or take-off value in the two-legged take-off is the 100% value for one leg, it was observed that the results in the one-legged take-off are 124% in the strength test, 192% in the semi-dynamic take-off (SDT-0) test and 196% in the dynamic take-off (DT-0). Comparable differences between the vertical take-off with both and with one leg is 114% (Soest et al., 1985). Relatively small differences in strength and take-off in the case of the vertical take-off and large differences in the take-off on the pendulum apparatus, may be due to the great velocity of motion in the latter tests, over 6 m/s. According to Hill's curve at high velocity little strength of muscle contraction is developed.

The take-off tests on the pendulum are included among the tests carried out at high muscles' velocity contraction. Therefore the summation of the strength of both legs does not actually influence the take-off effect. Hence the inconsiderable differences in these tests. In sport such an effect can be compared to throws with one or both hands (excluding coordination problems), or to horizontal jumps but not to vertical ones.

On the other hand it has been demonstrated that legs' strength (F) correlates positively with the take-off effect. The correlation, however, is greater in the case of the semi-dynamic take-off (SDT-0). The relative force F_{RE} which is equal to the amount of force per one kilogramme of body weight has similar though less significant connection with the take off. Correlation results are included in Table 3 and Figure 4. Correlations between the absolute strength (F) and the relative strength (F_{RE}) and relative loss ($\Delta h\%$) and absolute (Δhcm) are negative (Table 3 and Figure 5).

TABLE 3

Correlation coefficients (T) of absolute strength (F) and relative one (F_{RE}) with both kinds of take-off (SDT-0) and (DT-0) results and relative ($\Delta h\%$) and absolute (Δ_{hcm}) differences of these take-off. All the tests were performed two-legged. N = 13.

	SDT-0	DT-0	$\Delta h\%$	Δhcm
F	0.95	0.72	−0.81	−0.57
F_{RE}	0.73	0.36	−0.69	−0.60

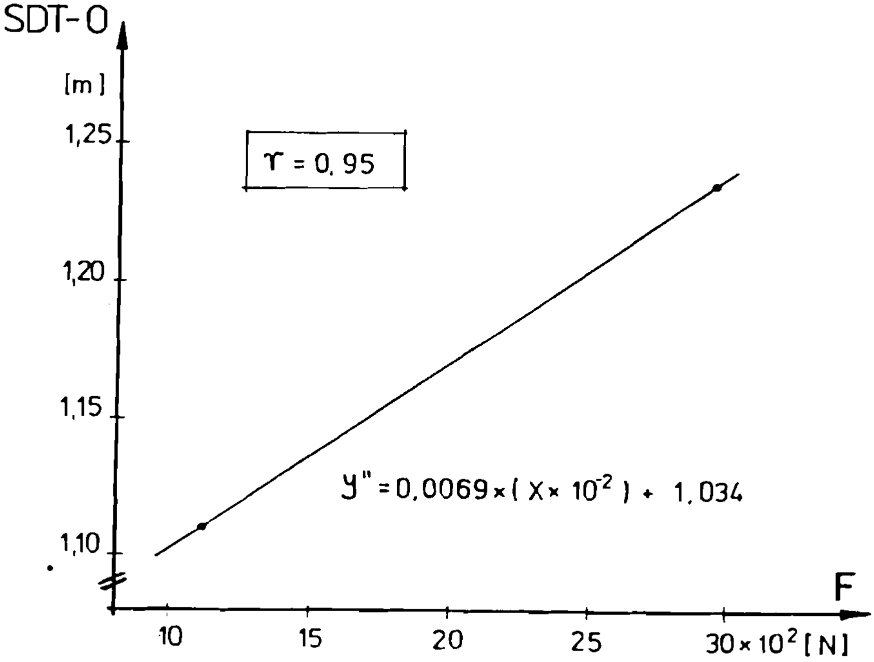

Fig. 4. Relationship between relative the semi-dynamic take-off (SDT-0) and the static strength of legs (F).

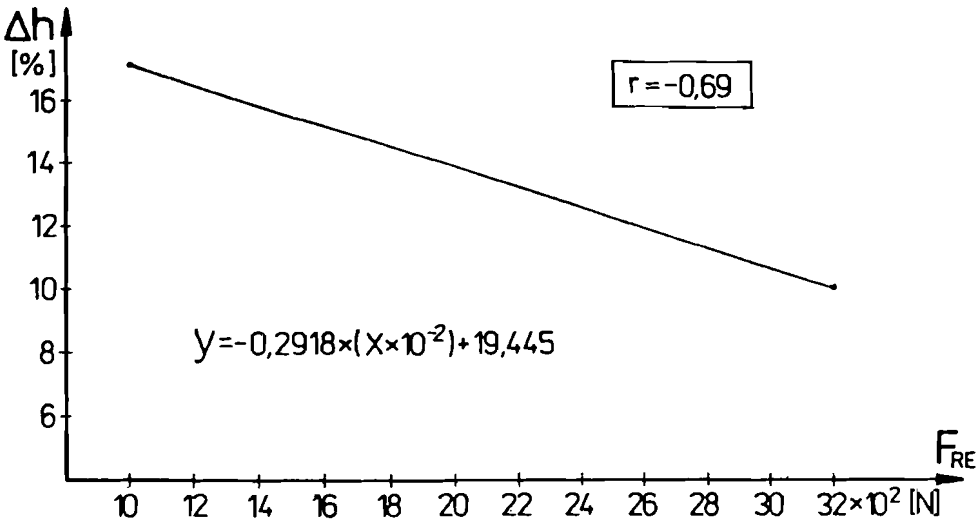

Fig. 5. Relationship between relative difference between semi-dynamic take-off and dynamic take-off (Δ h%) and relative strength (F_{RE}).

This means that the stronger the individual, the smaller losses he suffers in the semi-dynamic take-off in relation to his maximal abilities (dynamic take-off). This is a vital piece of information to strength-speed training in various sport branches.

CONCLUSION

The static legs' strength, which correlates better with the semi-dynamic take-off than the dynamic one is an important quality of volley-ballers and basket-ballers, the more so because there are take-off from a stopped position, so called situational take-offs limited in time and in the range of knee bending. Strength also plays an important role in these sport events because it levels the differences between the efficiencies of the take-off with a full pre-stretch and the one performed from an arrested position. The smaller correlation between the strength and the dynamic take-off with a pre-stretch (CMJ) may result from the fact that movement coordination, in order to release the elastic energy of muscles, is of greater importance (Bober et al., 1987). Strength training in those sport events in which such take-offs occur, similarly as in the case of the counter movement jumps, requires special attention being paid to developing greater power by decreasing the time of take-off and by connecting strength training with the technique of a given event.

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