Training Principles for Jumpers: Implications for the Special Strength Development

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ABSTRACT

Brazil is the leading country in South-American athletics, with jumping events among our most successful specialities. Recent top class results achieved by some Brazilian jumpers have been produced by a systematic approach, based on concepts firmly grounded on scientific data and

modern methodological trends. The most important principles we have followed to organise the jumpers' training, with special emphasis to the special strength development, are:

1. Short cycles is preferred to longer ones at the annual training organisation;
2. Special strength training must be done during all season, because training effects are absolutely specific;
3. Quality of training (technique and power produced at each repetition) is by far more important than quantity (tons lifted, or number of jumps performed).

INTRODUCTION

In South-America, Brazil has been the leading country in athletics, and the horizontal jumps are among our best events. Despite that, track and field has not reached the level of popularity that we would like, and the amount of youngsters involved with the sport is very low considering the huge population we have. However, even with few adepts, we have always been able to develop world class jumpers.

This tradition began in the 50's with Adhemar Ferreira da Silva, one of the greatest triple jumpers in history. Da Silva was followed by Nelson Prudêncio (Olympic silver medallist in 1968 and bronze medallist in 1972) and João Carlos de Oliveira (two Olympic bronze medals and World record holder for 10 years). We have also to mention Anisio Silva (7th at 1993 WC), Nelson Ferreira Junior (5th at 1997 WC in the long jump) and Maurren Higa Maggi (1999 long jump World leader; 9th best jump all-time, with 7,26m; 1999 and 2001 World Championships finalist; 2001 World University and Goodwill Games Gold Medallist) as successful Brazilian jumpers. Our tradition in horizontal jumping events is going on, with the young Jadel Gregório (21 years old), World University Games bronze medallist, and the promise Thiago Carahyba Dias, who won the long jump in Debrecen, at the II World Youth Championships.

We have the opportunity to work with many of these fine athletes, and we are convinced that these results have not been achieved by chance. Considering the space restrictions, we will try to present an outline of the principles we have been following to guide the long term planning of our athletes' careers, and their implications for the special strength development.

LONG TERM TRAINING ORGANIZATION

We firmly believe in the statement that it takes 6 - 10 years to develop a high performance athlete (ARBEIT, 1998; PILA-TELEÑA, s/d). In order to be considered a high performance athlete, it is not enough to produce a big jump: You have to be consistent! Following this definition, Maurren Maggi belongs to such group. By the other hand, Jadel Gregório jumped in March 2001 a then World leading 17,13m. His second best jump was 16,48m at that time, so it was clear that, although very gifted, he had some work to do before join this group. A string of good efforts (16,98m; 16,94m; 16,83m) toped by his bronze medal performance (16,92m) at World University Games now allow us to include Gregório among the best jumpers in the World.

In order to guarantee the future success, we need to plan the entire career of the athlete. We have done it splitting the entire process in phases, as can be seen in figure 1 and table I.

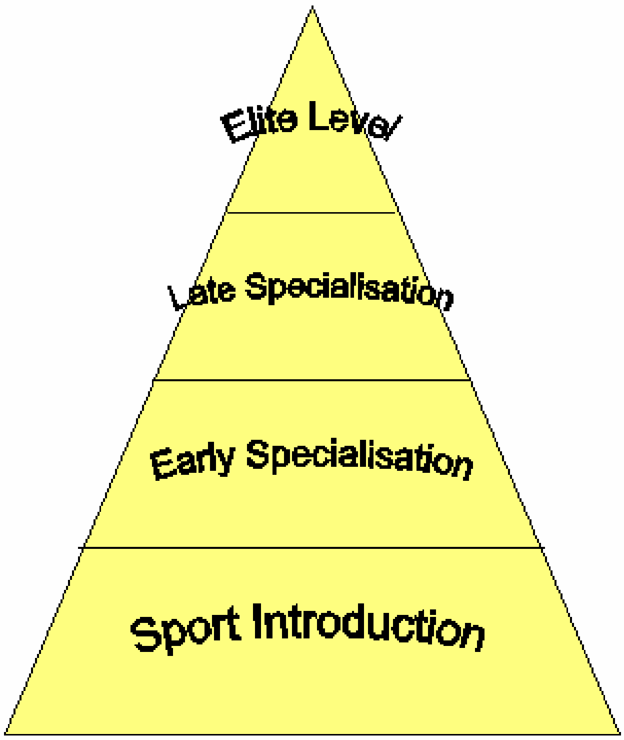

Figure 1. Phases of athlete’s development. Based on THUMM (1987), GAMBETTA (1986), PILA-TELEÑA (s/d) and THOMPSON (1991).

PHASE	INITIAL AGE	DURATION	GOALS AND CHARACTERISTICS
SPORT INTRODUCTION Sub-phase I: Foundation Sub-phase II: Basic Training	9 a 11 years (prepubescent) Sub-phase I 12 a 13 years (pubescent) Sub-phase II	4 a 5 years	• Basic technique learning in different events • Self-steam development • General and multilateral training • Games, fun activities • Adapted competitions
EARLY SPECIALISATION	14 a 15 years	3 a 4 years	• Technique refinement • Development of positive competitive behaviour • Choice of a group of events • More formal competitions
LATE SPECIALISATION	18 a 20 years	3 a 4 years	• Technique mastering • Choice of one or two events • Increased frequency and intensity of training and competitions
ELITE LEVEL	21 a 24 years	Indeterminate	• Realisation of the technical, physical and psychological potential, expressed by elite results achievement

Table I: Phases of athlete's development. Based on THUMM (1987), GAMBETTA (1986), PILA-TELEÑA (s/d) and THOMPSON (1991).

ANNUAL CYCLE ORGANIZATION

Since the sixties, periodisation is considered the most effective way to organise the annual cycle of training. Nowadays, we see a lot of different proposals regarding training organisation, all of them very difficult to be scientifically checked. What we consider important is to select sound principles and to take our decisions based on them. Despite all discussion seen among the sports training theorists, some statements are hardly disputed:

- General training can hamper the development of special capacities when they are done concurrently (DUDLEY & DJAMIL, 1985; HUNTER et al, 1987). Therefore, high performance athletes should not try to develop general capacities beyond the strictly necessary level, and these capacities should be developed at the early stages of training;
- High performance athletes are supposed to be submitted to specific training all season long. When we talk about jumpers, this specificity includes the choice of the best exercises, considering the type of strength and the goals to be reached (Figure 2);
- The training control and prescription taking into account the volume of work have been overestimated. Proposed values usually found in the literature are too high to be done with quality in a drug-free environment;

- The biggest emphasis should be given to training quality, so monitoring athletes performing special exercises is very important. There is no problem if high performance athletes – who possess a high ability to exploit their special capacities at each repetition of a given exercise – perform less repetitions than developing athletes, as long as the monitoring shows that quality has fallen bellow the desired level;
- We can repeat the phases of sport shape development (acquisition, maintenance, and temporary loss) more often than thought in the past. The formal structure with two competitive periods rigidly determined has been abandoned. Short cycles are better than long ones (TSCHIENE, 1989) to prevent over-training and performance stagnation provoked by the "complete adaptation" phenomenon.

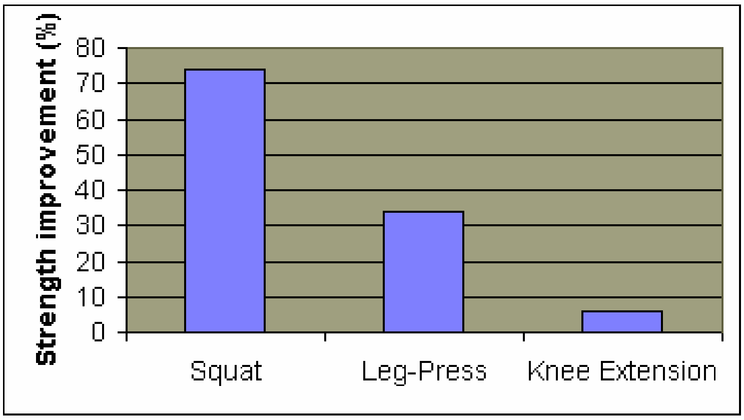

Figure 2: Specificity in strength training. Squat was the training exercise. Modified from FAHEY (1998).

Figure 3 shows a sample model of periodisation with elements of block structure, based on which our athletes' training has been organised.

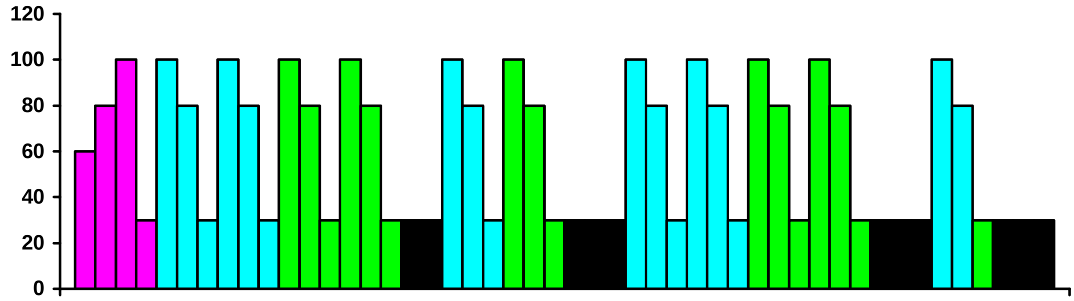

Figure 3: Training organisation based on block structure. Modified from COMETTI (1991)

= Introductory Block = SPC Block (Special Physical Conditioning) = Technical Block = Competition

STRENGTH MANIFESTATIONS IN ATHLETIC JUMPS

Strength is the capacity of skeletal muscle to produce maximal tension or force, at a given velocity. Tension generated by the muscle has the tendency to shorten it, changing the joint angles and then producing movement. Strength is a determining factor in jumping events, and can be manifested in different ways according to its speed and endurance interrelationships. (Figure 4).

The most important strength manifestations for jumpers are the elastic and the reactive strength, but proper levels of strength endurance and maximal strength should be developed to assure the base for improvement of special manifestations and to prevent injuries.

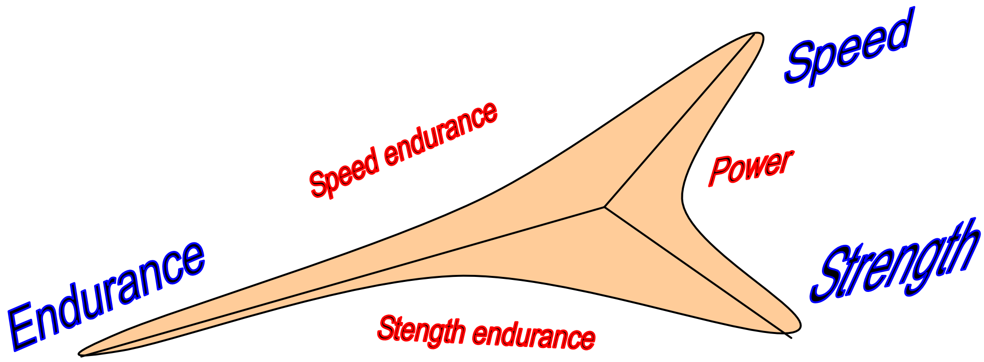

Figure 4. Three-dimensional speed, strength and endurance interrelationships. Based on NEUMANN (1988).

Even though the traditional approach of developing strength following the sequence strength endurance => maximal strength => special strength still dominates, new data have shown that training transformations are not straightforward as thought in the past. Actually, when stimulus to development of strength endurance or maximal strength last more than eight consecutive weeks, deleterious effects on special strength (BOSCO, 1985) and on the muscle's microstructure (WIEMANN & TIDOW, 1995) can be noticed. On the other hand, ANDERSEN, SCHJERLING & SALTIN (2000) found that when muscles are subjected to a heavy weight training program, the number of type IIb fibres decreases (from 9% to about 2%), as they convert to type IIa fibres. However, after a period of detraining, rather than just returning to initial levels, the relative amount of IIb fibres increases up to 18%.

These data are very interesting, and justify the use of heavy strength training for 6-9 weeks (but not more, in order to avoid type I fiber development) during the first half of the SPC block, as well the inclusion of brief periods (2-3 weeks) during the year devoted to development or maintenance of maximal strength. A tapering phase will later bring the opportunity to reconvert IIa muscle fibres into faster IIb types. Complex method (contrast) has been increasingly popular among jumpers, and most strength training programs that we use follow this principle. This method tries to increase the possibility of transference of the effects in direction of the real competitive situation, playing with the central nervous system by varying type and intensity of stimulus. Another interesting concept - hipergravity - was introduced by BOSCO (1985b), and SANDS & co-workers (1996) corroborated his results: it seems special weighted clothes bring important benefits to power events specialists, what gives support to the inclusion of this procedure in jumpers preparation.

Motor units recruitment during training for strength and muscle power (Size principle and its exceptions)

It has been clearly shown that motor units recruitment follows a sequence where the small units (fibres type I) are first recruited, and are then progressively followed by bigger units (types IIa and IIb). Even at the early stages of a maximal muscle action, fibres type I are recruited first. (Figure 5). However, there are exceptions to this principle, and it is very important they are known by the coach.

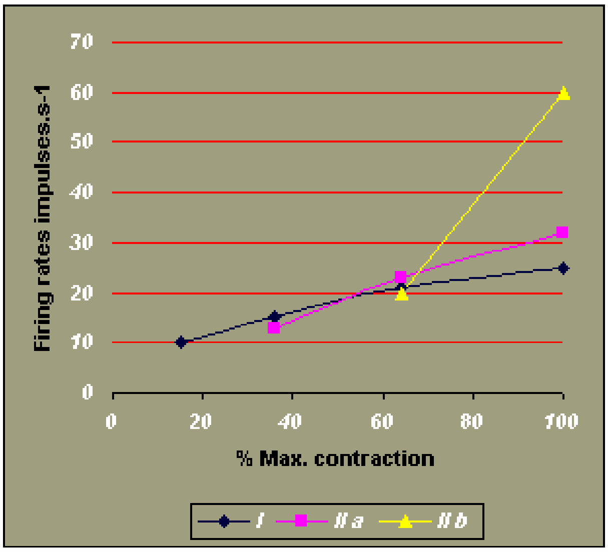

Figure 5: Size principle. Modified from SALE (1992)

BOSCO (1985a) noticed a negative relationship between development of maximal strength and special strength in elite Italian jumpers. Even though he did not suggest eliminating maximal strength training, he recommended limiting duration of this training period to a maximal of 8 weeks. He justified that by the fact that after 8 weeks, undesired ultrastructural changes in the muscles can be seen. Type I fibres hypertrophy would hamper elite performance (Figure 6). Before such changes happen, other training methods able to develop type II fibres (mainly IIb) should replace maximal strength methods. High velocity eccentric activity shows a recruitment pattern that is exactly the opposite to the above exposed, the same happening with trained ballistic activities. It seems type II fibres are first recruited in these cases because they need less time to relax after the action, what is necessary for a better control during fast eccentric actions (HOWELL, 1995). Plyometric training is a method to improve strength and muscle power with a selective recruitment of type IIb fibres, so it has an important place in our program.

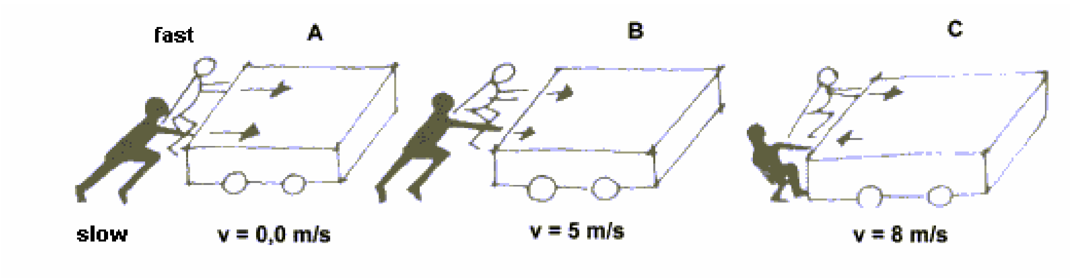

Figure 6. Interactions between slow and fast fibres during dynamic and static action. Reproduced from BOSCO (1985a).

Strength and muscle power training: responses and adaptations

Usually, training leads to a rapid gain in strength on the early stages, without increases in muscle mass. This initial adaptation can be explained by better recruitment patterns of motor units, and is called *neural adaptation (learning).* Selective recruitment of a higher number of motor units (mostly Type IIb), activated at a higher frequency, and with good synchronisation, are the neural factors that allow a higher strength and muscle power (SALE, 1992).

Structural adaptations (hypertrophy) occur later, as a result of prolonged strength training. Hypertrophy can be selective (only in certain types of motor units, accordingly with training emphasis), and can be result of increased amounts of non-contractile (sarcoplasmatic) and/or contractile proteins (myofibrillar) (SIFF & VERKHOSHANSKY, 1998) (Figure 7).

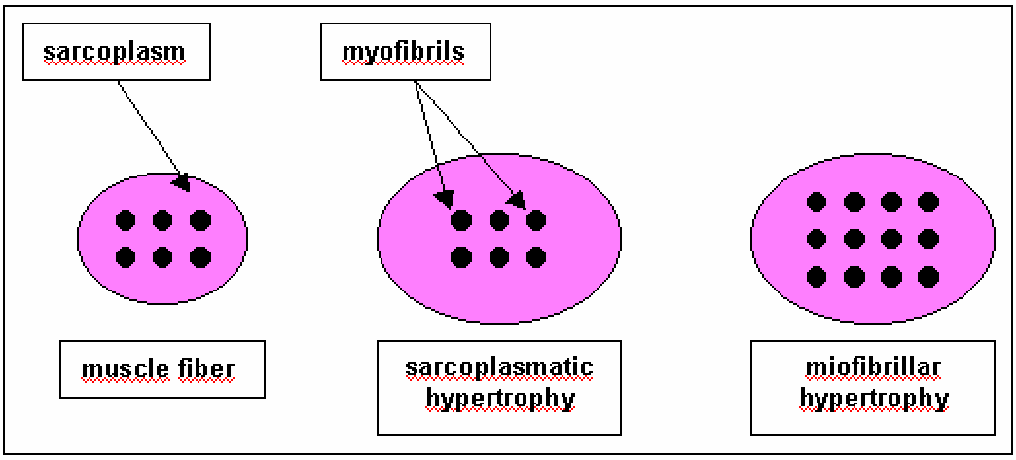

Figure 7. Different kinds of hypertrophy. Modified from SIFF & VERKHOSHANSKY, 1998.

We can find in the literature an interesting response to maximal voluntary contractions (MVC) known as *post-tetanic potentiation* (SIFF & VERKHOSHANSKY, 1998; GÜLLICH & SCHMIDTBLEICHER, 1996). When a muscle does a maximal isometric action for about 5 seconds, there is a reduction in its explosive strength that lasts a few minutes. After that, a facilitating phenomenon occurs, and the explosive strength is significantly increased. New studies are necessary to define a protocol of MVC during competition warm-up, but this is surely an amazing possibility for the specialists in power events.

PLYOMETRICS

Since the 60s, coaches and scientists around the world have been searching training means and methods to improve the storage and reuse of elastic energy in skeletal muscle during the stretch-shortening cycle (SSC). The so-called plyometric exercises are able to do that. They are defined as exercises that "activate the stretch-shortening cycle of skeletal muscles, inducing the elastic, reflex and mechanical potentiation" (MOURA, 1988). Several factors interfere with this potentiation, changing the capacity to generate positive work during SSC. Among them, the most important are amplitude and speed of eccentric phase, as well the coupling time between eccentric and concentric phases (CAVAGNA, 1977). The most favourable situation in track and field combines small amplitude, high speed of the eccentric phase and a short coupling time.

Depth jumps, and its many variations, are the most popular plyometric exercises built to improve lower limbs explosive strength (Figure 8).

The drop height determines the eccentric load, and its control is very important. Even though recommendations of drop heights from 0,38m to more than 2,00m can be found in literature (LUNDIN, 1985), most authors believe in the concept of "optimal height". NASSER (1990) claims that drop jump tests are usually applied by coaches, successively increasing fall heights and stopping when the height of the jump after the fall ceases to increase. Optimal height for training is considered the one that allows the best jump after the free fall (BOSCO, 1985 a). Figure 9 shows results of a female long jumper (personal record = 6.20 m) doing drop jumps from heights of 20, 40, 60 e 80 cm. In this situation, a fall from 60 cm was optimal to the traditional depth jump, and 80 cm to the modified depth jump (MOURA, 1993). However, other issues should be taken in account when we choose the best eccentric load to each athlete.

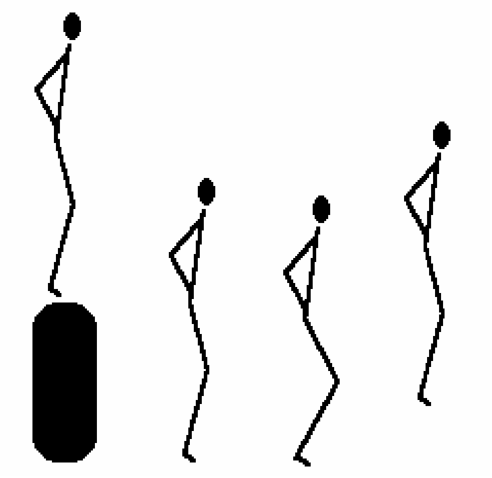

Figure 8. Traditional depth jump (SPT).

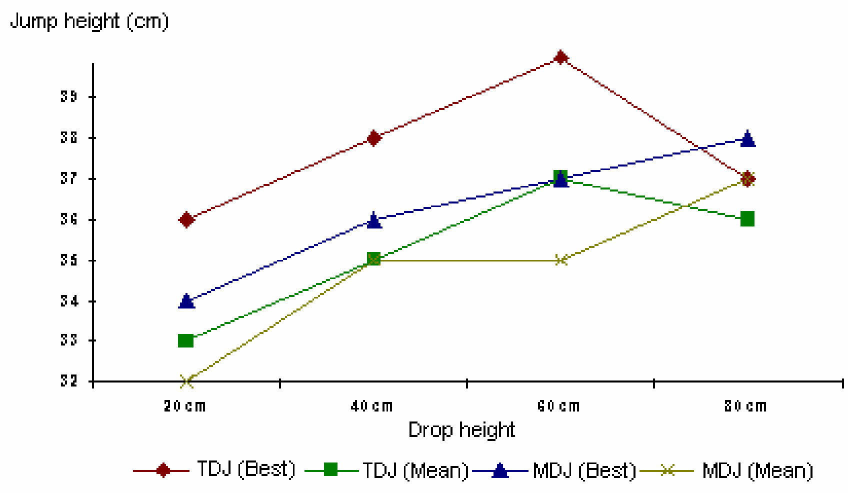

Figure 9. Jump's height after falling from different heights, with two techniques. The subject was a female long jumper of international level (PB = 6,20m). TDJ = Traditional Depth Jump; MDJ = Modified Depth Jump.

Figure 10 shows two curves of ground reaction forces (GRF) obtained during depth jumps. Curve A was generated by the jumper above mentioned and curve B by a beginner. We can notice that the shapes of these two curves are very different from each other. The most important difference is the first peak showed at the beginner's curve. This peak represents the *passive forces*, and is not seem in the elite jumper's curve. High passive forces have a great potential to lead to injury, and do not contribute to performance. The second peak represents the *active forces*. The passive peak in depth jumps is associated to heel contact with the ground. So, if the athlete touches the ground with the heel after the drop, the height shall be reduced. If this measure is not enough to guarantee that the heels do not touch the ground, the use of depth jumps in training should be postponed. (MOURA, 1994).

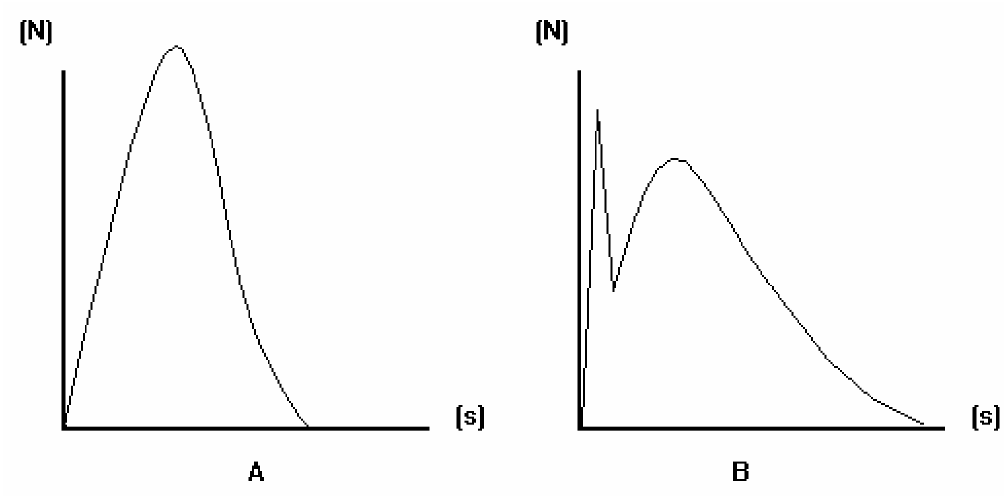

Figure 10. GRF's curves during depth jumps. A: elite jumper; B: beginner

Even though plyometric training should not replace weight training (actually, both co-exists in the special strength development of jumpers), its variations are far more effective to develop the RFD (*rate of force development*) – one of the most important components of special strength for this population – than the use of heavy weights (Figure 11).

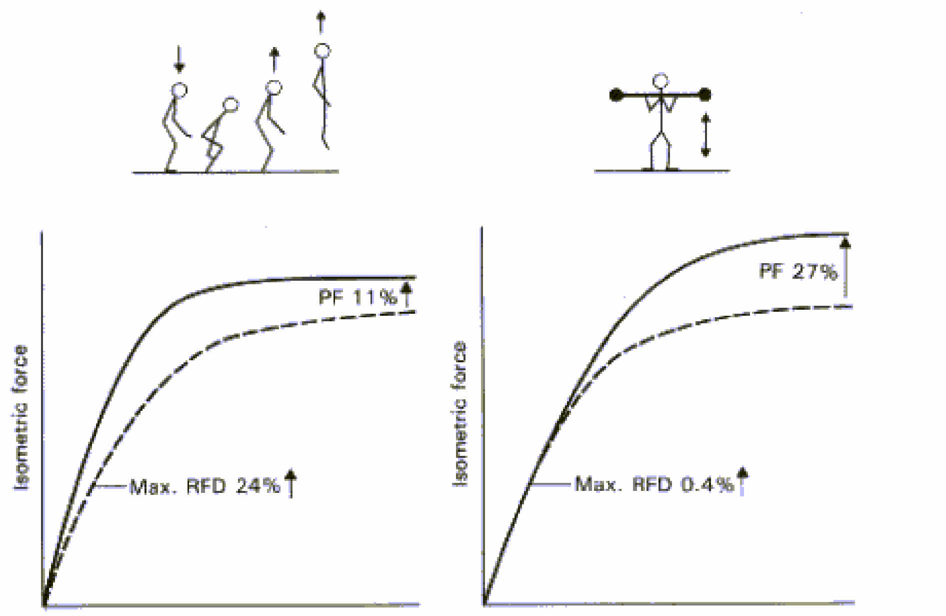

Figure 11. Effects of jumping training and heavy weight training on Maximal Strength (PF) and Rate of Force Development (RFD). Partially reproduced from SALE (1992).

Force-velocity curve

Classical work done by Hill shows the inverse relationship between force produced by the muscle and its shortening speed, both in isolated and *"in-vivo"* muscle. Figure12 shows this curve, easily reproduced through the use of vertical jumps with increasing loads. Three long jumpers, of national and international level (personal records: 8,00m, 7,44m and 7,44m) performed vertical jumps with loads from 0 to 30 kg. It is clearly shown that performance decreases while the load increases, what is absolutely predictable. If we observe with more attention, we see other interesting information. FRW and MRC are in inverted positions at the two extremes of the curve, showing they have different characteristics of explosive strength. Individual characteristics or a different training orientation can explain this difference. It is known training displaces each point of the curve upward and to the right, but also modifies the shape of the curve, changing some regions more than others do. Longitudinal follow-up can show if training is balanced or it is influencing any of the components of explosive strength in the wrong way.

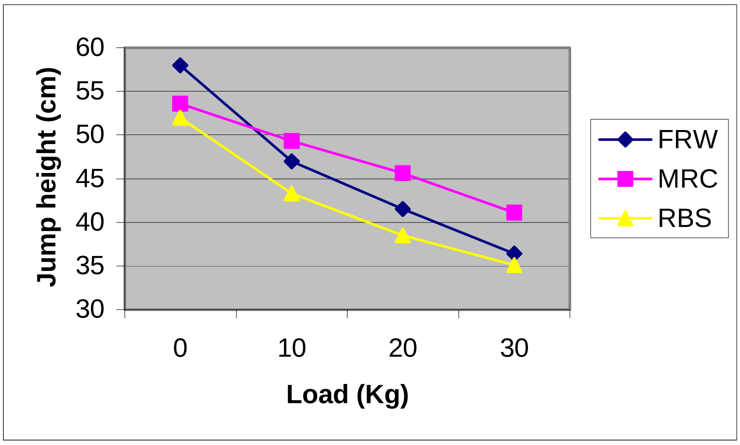

Figure 12. Force-velocity curve for three male long jumpers, built with vertical jumps data (see text for explanation).

Force and power production with different loads

Strength training of specialists in jumping events should have the aim of developing maximal power in short time. Figure 13 shows force-velocity-power relationships, and makes clear that in order to develop power loads must be optimal, not maximal. BOSCO (1991) suggests the use of loads equivalent to 35-40% of 1 RM, which allows the expression of 35-45% of the maximal velocity of the same unloaded movement. When heavy loads are used, and then bar velocity is low, it is important try to move the bar as fast as possible: YOUNG and BILBY (1993) have demonstrated that the intention (to move the bar fast) is as important as the actual speed of the bar if our aim is to develop power.

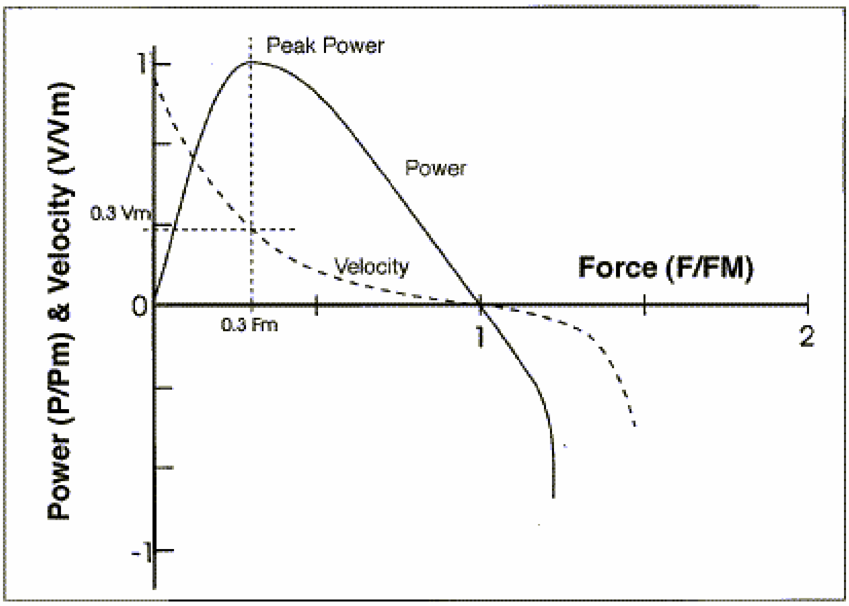

Figure 13. Force - velocity - power relationship for skeletal muscle. Vm, Pm, and Fm are maximal movement velocity, maximal power output, and maximal isometric force output, respectively. Reproduced from KRAMMER and NEWTON, 1994.

External pull support: facilitation to create a new motor program

RITZDORF (1998) suggests that decreasing the external loads when performing jumps is a good stimulus to develop the explosive strength's velocity component. He says that new motor programs – predominantly fast – can be developed with the systematic use of some facilitation method (like external pull supports), and that these short time programmes can be reproduced when the facilitation is removed. Even athletes predominantly fast, but without a good level of strength, could lose some characteristics of their fast motor programs if they do not have the opportunity to train them due to the low level of physical condition. We use surgical tubes attached to belts to create a vertical traction that decreases the weight of the jumper, so he can jump with very short contact times and produce high muscle shortening speed. Considering this is a method that provokes a central nervous learning effect, it is used by athletes of all age groups – it is a special method, but not restricted to elite athletes.

CONCLUSION

Different methods of training organisation can lead to high level performances. There are also many means and methods to develop strength for jumpers, all of them able to create the prerequisites of elite performance. We wanted to present here our interpretation of present scientific and methodological knowledge, and briefly to show how we use this knowledge in our daily practice. We believe that, more important than give detailed information about the day-by-day procedures is to define clearly principles and concepts, and take decisions based on them. Just to remind, the most important principles we discussed here were:

1. Short cycles are better than longer ones at the annual training organisation;
2. Special strength training must be done during all season, because training effects are absolutely specific;
3. Quality of training (technique and power produced at each repetition) is by far more important than quantity (tons lifted, or number of jumps performed).

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