A Theoretical Model of Strength Training

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Introduction

Most sports require above average strength and power levels, and many (e.g., football, shotputting, weightlifting, etc.) require great strength and power. Therefore, many coaches, athletes and sport scientists have a considerable interest in the investigation of strength-power training methods.

The purpose of this paper is to present a theoretical model for strength-power training and to present supporting data and observations. The model consists of four phases.

1. *Hypertrophy:* high volume*—low intensity**
2. *Basic-Strength:* moderate volume —high intensity
3. *Strength-Power:* low volume—very high intensity
4. *Active Rest:* very low volume—very low intensity

A review of literature indicates that most sport scientists generally recommend 3 sets of 6 RM as the optimum method of strength training (Clarke, 1973). More recently one set (Darden, 1975, Jones, 1976) or multiple sets to exhaustion (Silvester *et al.* 1982) have been recommended as the best method of developing strength. However, our research and observations indicate that the above model produces superior strength-power gains when compared to these and other methods.

Basic Principles

Garhammer (1979) has presented an overview of the "General Adaptation Syndrome" (G.A.S.—Figure 1) as it relates to exercise and training. Briefly, G.A.S. suggests that an athlete may be subject to 3 different phases of adaptation during a training program. The first phase relates to the initial response to a stimulus (alarm stage). This could represent a temporary drop in performance caused by soreness/stiffness dur-

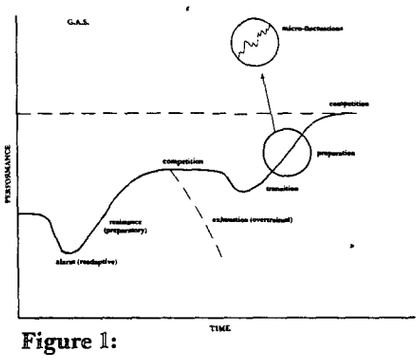

Figure 1:

ing the first few days of a new training program or cycle. The second phase (resistance) corresponds to the period of training during which the athlete's body makes a number of biochemical, structural, biomechanical and perhaps psychological adaptations in a manner leading to increased performance. However, if the total stress imposed by training (and other facets of the athlete's life) are too great, then the third stage of G.A.S., exhaustion or "overtraining," is reached, and the desired adaptations are no longer possible (Figure 1). Other stresses (Figure 2) besides the training can also contribute to "overtraining" and the coach-athlete must be aware of this in planning a training program.

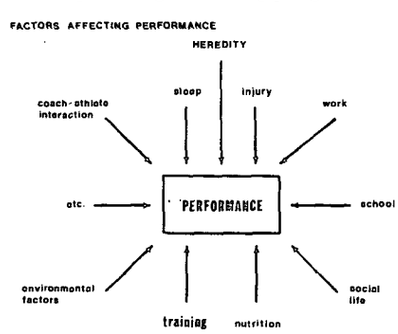

Figure 2:

The basic principles of training are frequency, duration, intensity, variation, and, most importantly, specificity (Edington and Edgerton, 1976; Tschiene, 1979). These principles must be interwoven in a fashion which reduces the possibility of "overtraining." The concept of "periodization" (Matveyev, 1972; Tschiene, 1979) embodies these principles and seeks to reduce overtraining and bring performance to optimum or peak levels. In general, the potential for overtraining is reduced by variation in volume and intensity and in the amount of technique or other specialized work performed (Figure 3a and b). The variation in volume and intensity occurs over the entire training period (macrocycle) within smaller periods, perhaps several months (mesocycle) and even weekly (microcycle).

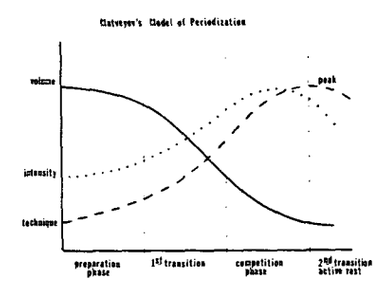

Figure 3a.

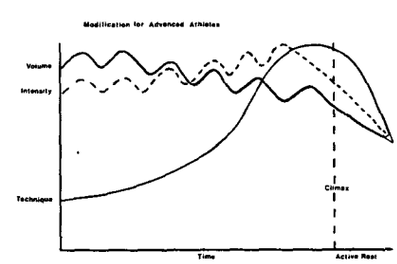

Figure 3b:

Table 1 shows a hypothetical model of strength-power training conforming to the basic tenants of "periodization." To date eleven (11) studies have been completed investigating the effectiveness of the hypothetical model compared to other strength training programs. Most of these studies have been on the mesocycle level lasting 6-15 weeks. The subjects have included untrained men and women, a high school football team, a women's softball team, advanced weight trainers, weightlifters, and various other athletes. In addition, the authors have worked with and helped coach several college teams and national and international class athletes which allowed them the opportunity to collect additional empirical data as to the effectiveness of this model of strength training. These studies have been an ongoing project over a period of the last 4½

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Table 1. A Hypothetical Model of Strength Training (Associated with Matveyev's Periodization Table).

Preparation	Transition 1	Competition	Transition 2 (Active Rest)		
Phase	Hypertrophy	Basic Strength	Strength & Power	Peaking* or Maintenance	AR
Sets[x]	3-5	3-5	3-5	1-3	S
Reps	8-20	2-6	2-3	1-3	e
Days/Wk	3-4	3-5	4-6	1-5	e
Times/Day	1-3	1-3	1-2	1	T
Intensity Cycle (weeks)**	2-3/1	2-4/1	2-3/1	—	e
Intensity	low	high	high	very high to low	x
Volume	high	moderate to high	low	very low	t

*Peaking for sports with a definite climax or maintenance for sports with a long season such as football.

**Intensity Cycle—ratio of the number of heavy training weeks to light training weeks.

-[x]Does not include warmup sets.

years. A paper has been published which describes the basic concepts and presents some of the early research data and observations as to the superiority of this model of training over more traditional methods (Stone, O'Bryant and Garhammer, 1981). A second more detailed manuscript is currently in preparation.

Results of Research

Various measurements have been used in the eleven studies. The following measurements were used in most or all of the studies:

1. Leg and hip strength (1RM squat)
2. Leg and hip power (vertical jump and Lewis formula)—(Lewis formula = $4.9 \times BW_{kg} \times VJ_m$)
3. Upper body strength (1RM Bench Press)
4. Body weight
5. Body composition [% fat and lean body mass (LBM)] measured by hydrostatic or skinfolds methods.

Typically the following changes would be expected through the various stages. An example of these changes over 15 weeks is shown in Figures 4-8.

Hypertrophy—This stage is an early preparation designed to enable the athlete to adapt his physiology so that he is better **prepared** to perform high intensity, high quality strength-power training. During this phase two important adaptations, **beyond that of traditional programs**, can be expected based on our research and that of others. First is a positive change in body composition, a decrease of % fat and an increase in LBM (hypertrophy) (Stone, O'Bryant and Garhammer, 1981; Alexeev and Roman 1976; Morehouse and Miller, 1976). The increase in muscle mass (hypertrophy) (LBM) increases the potential of the athlete to gain strength and power (Morehouse and Miller 1976). The second important adaptation brought about by high volume strength training is an increase in short term endurance (an expansion of anaerobic capacity). (Sale and MacDougall, 1981; MacDougall, Ward, Sale and Suttin, 1977; Andersen and Kearney 1982). This expansion of anaerobic capacity may be of great importance in the reduction of fatigue during the later phases of higher intensity work. We have observed that these adaptations are best accomplished by using 3-5 sets of 10 repetitions.

Leg and hip strength and power will increase during this phase to about the same degree as that seen using 3x6 RM during short term (2-4 weeks) training with untrained subjects. The bench press may show only slight increases or no change. However, advanced athletes may actually show slight decreases in their maximum 1 repetition strength, especially as it concerns lower back, leg and hip strength. This is likely due to fatigue. It must be remembered that this is a **preparation** phase primarily designed to increase LBM and short term endurance (Figures 4-8).

Basic-Strength Stage—Basic strength refers to the IRM strength gain in movements which are basic to the sport in question. In most sports this refers to squatting, pulling, and pressing movements. After the hypertrophy stage, strength can be trained using 3 sets of 5 repetitions. This represents a **late stage of preparation**. The gain in basic strength provides the appropriate foun-

Model — — — — — —

Traditional — (eg; 3x6, pyramids, etc.)

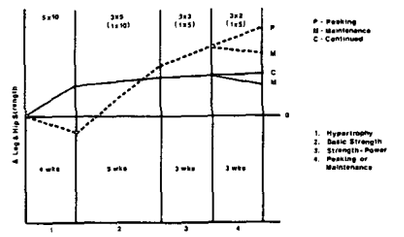

Figure 4: Example, changes in leg and hip strength (1RM squat) compared to traditional methods of training.

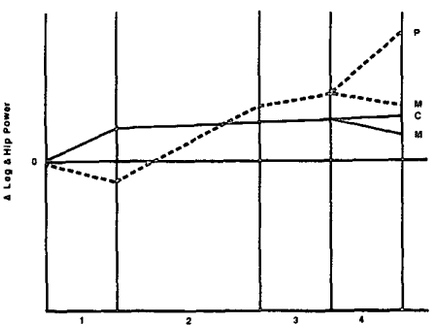

Figure 5. Example, changes in upper body strength (1RM Bench Press) compared to traditional methods.

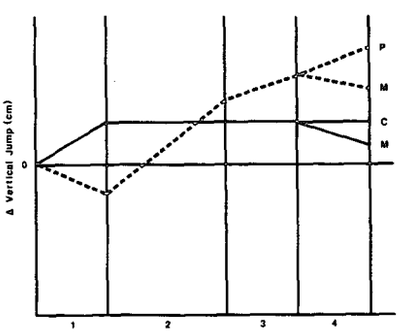

Figure 6. Example, change in vertical jump compared to traditional methods.

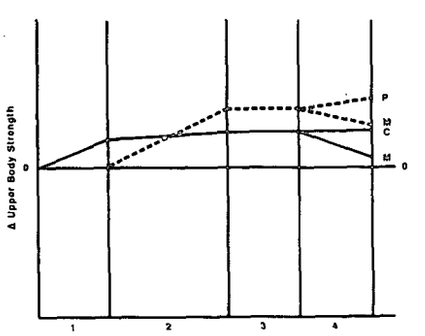

Figure 7. Example, change in leg and hip power (Lewis Formula) compared to traditional methods.

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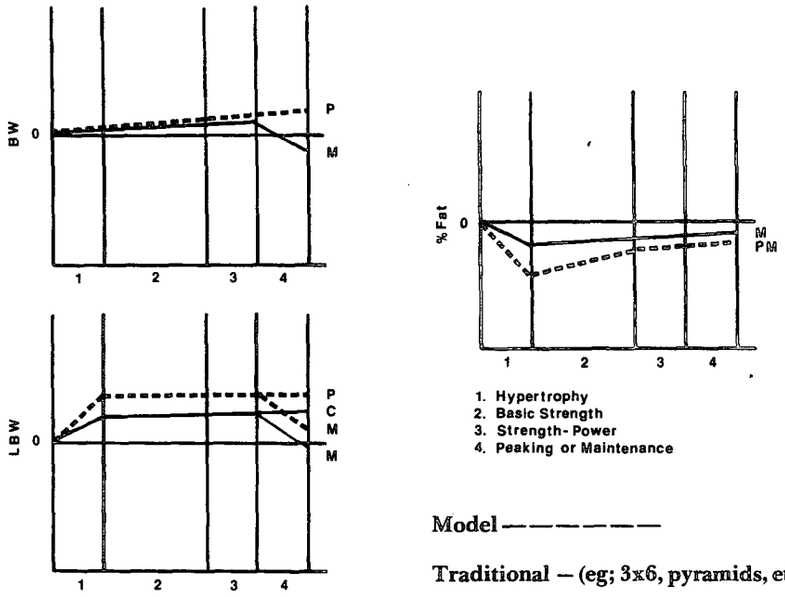

Figure 8. Example, changes in body weight and body composition compared to traditional methods.

(From page 37)

dation for power specialization and further high intensity work. Strength, especially of the leg and hip, increases sharply during this phase (Figures 4-7).

Strength-Power stage—Following the concepts of Matveyev and the principle of specificity, strength and power can be brought to higher levels using 3-5 sets of 2-3 repetitions. A sharp rise in vertical jump and power can be expected during this phase. This is likely due not only to increased leg and hip strength but also to the reduction of fatigue in response to decreasing workloads (volume) (Figures 4-7).

Peaking-Maintenance Stage—Again conforming to specificity of training and the concept of periodization, power and strength may be brought to a peak by further volume reductions accompanied by increasing intensities. In many sports, for example olympic weightlifting, an increasing emphasis should be placed on speed and technique work through the final stages with the greatest emphasis during the peaking phase. Two or three sets of 1 to 3 repetitions have been used by college-age lifters (after warm-up) during a peaking phase with excellent results (Figures 4-7).

In sports such as football and basketball in which there is a season of considerable length, with no clear-cut climax, a maintenance program is necessary. Three sets of 2 or 3 repetitions with moderate to heavy weights are suggested. The frequency of training will largely depend upon the sport, but at least 2 days a week are recommended. By keeping the total volume of strength training low, this will greatly reduce the possibility of overtraining, and will help to maintain high strength-power levels. This is far more preferable to no in season training which results in marked power and strength decrements (Table 1).

Further Thoughts

A most important factor in this model of training is the initial change in body composition. As previously stated the increase in LBM potentiates strength-power gains. This should not be dismissed. The authors' observations and those of others strongly suggest that LBM may well be the most important factor contributing to strength-power gains (Alexeev and Roman, 1976; Komi, 1979; Stone, O'Bryant and Garhammer, 1981; and Ward, Groppel and Stone, 1979). Early studies by the authors suggested that as the volume of work was reduced, during the late training steps, percent fat began to increase and LBM had a very slight tendency to decrease. Later studies suggested that this negative effect on body composition may be reduced by introducing a warm-down set of 1 x 10 repetitions. Even with these warmdown sets included there is a sharp decrease in volume across the training cycle.

Notice the sharp break in volume and the sharp increase in intensity from phase to phase (Table 1 and Figures 3a and 3b). It has been observed that this produces better progress, especially in advanced athletes. This observation is confirmed by other researchers (Tschiene, 1979). Possibly this phenomena is due to reducing monotony or perhaps "shocking" the central nervous system.

Advanced athletes may require greater planned variation in volume and intensity in order to continue progressing. Figure 3b shows a method by which this can be accomplished. Basically this is concerned with introducing microcycles into the overall cycle (several microcycles could make up a mesocycle); training 2-3weeks with increasing loads followed by an unload week. Additional variation, such as changing the type of exercise or speed of training may also be helpful.

Active rest is another important factor which contributes to long term progress. If an athlete simply moves right into hard training after peaking or after a season of playing some sport, progress will be diminished. Complete rest, while sometimes necessary, also does not seem to produce as good a result as active rest. Active rest refers to participating in some other sport or occasionally your own at very low volumes and intensities. The length of active rest depends upon the sport and the athlete's needs. For example, the weightlifters at Auburn University (after peaking for a meet) are encouraged to take a few days off, then to play racquetball or basketball for a few additional days before beginning the next cycle. After two or three cycles they will take 3 or 4 weeks and do nothing, as far as weight training, but very light technique work. The reasons for the necessity of active rest are not completely clear, but certainly it contributes to the reduction of physical and mental (especially emotional) fatigue. Thus it reduces the possibility of overtraining during the next cycle. A typical training year is shown in Figure 9. (Notice the heavy emphasis on preparation during the early part of this training year [macrocycle].)

Summary

While no clear-cut distinction between "muscle training" and "nerve training" can be made, the approach presented has emphasized the muscle during the early preparation (high vol-

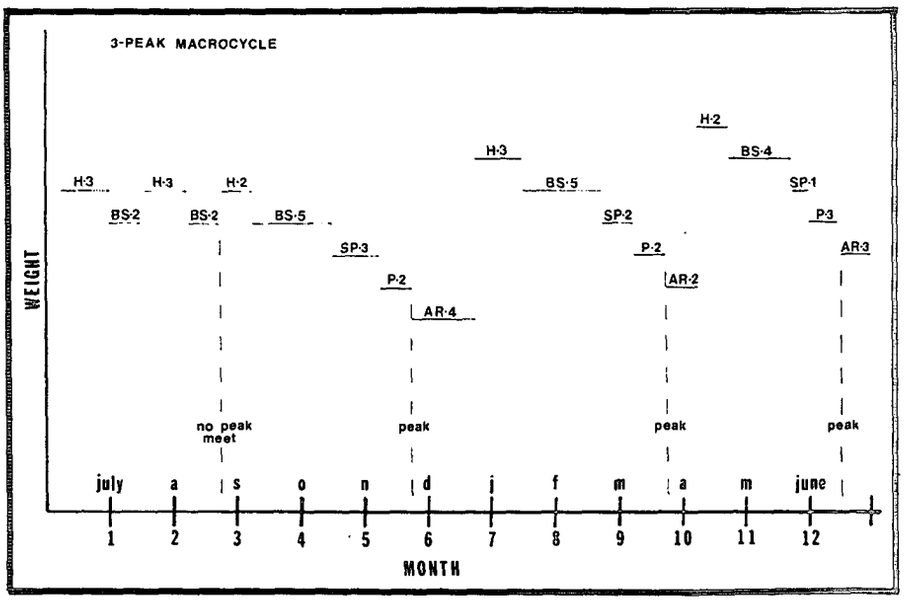

Figure 9. Three peak macrocycle

H = Hypertrophy **SP = Strength Power**

BS = Basic Strength **P = Peaking**

***The number beside the letter indicates the number of weeks spent in that subphase.**

***The weight of each subphase is proportional (in general) to the amount of weight used in each identical subphase.**

ume), then emphasized the central nervous system (high intensity and increased technique work) during the later stages of training. The authors' research and observations, that of other researchers, and the subjective evaluations of athletes and coaches who have tried this method suggest this to be a superior method of strength-power training.

This model of training has been compared to various methods of strength-power training including 3 sets of six RM, pyramiding, low repetitions and various sets to exhaustion (1-3). Based on these comparisons the following conclusions were reached:

1. The model produced superior gains in leg and hip strength (1RM) (10 of 11 studies).
2. The model produced superior gains in leg and hip power (VJ and Lewis formula) in all 11 studies.
3. The model generally produced superior gains in upper body strength (1RM Bench Press). (However, a few studies showed equal gains when compared to 3 x 6 RM and pyramiding over a short term [6-12 weeks]).
4. Positive changes in body composition (% fat and LBM) were greater in those subjects using the training model in most of the 11 studies. This was especially evident after high volume training (sets of 10).
5. Based on cycle ergometry of increasing intensity to exhaustion, the model produced greater gains in short term endurance. This was especially apparent after high volume training (sets of 10).

While this method of training is not the final answer, it is based on sound concepts and principles and will provide the coach-athlete with a superior training program. ●

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*Volume: Total number of repetitions

**Intensity: Average weight of the implement.