2.1 The Training Process

2.1.1 Basic Concepts of Periodization

Historical Overview - Rome and Greece

Ever since the beginning of muscle strength training, the same question has persisted: What can be done to improve strength? We can find this question in ancient literature. In the second century BC., the famous Roman physician and philosopher Galen had proposed in his treatise, “Preservation of Health”, an interesting method of exercise categorization that began with a series of "strength exercises, but without speed", to then develop "speed separate from strength", and finally "performing intense exercises that combine strength and speed" (as cited in Issurin, V.B. 2010, p.191).

Another great example comes from ancient Greece: the famous Philostratus, "the Athenian", also in second century BC, in his essay titled *Gymnasticus*, he described the preparation of an Olympic cycle made up of ten months of general training followed by a one-month period of specific training in the city of Elis prior to the games. In this case, its similarity with current practices is startling. Its sequence of short, medium and long loads within four-day training cycles are a brilliant illustration of the approach to periodization in the Ancient Age (as cited in Issurin, V.B., 2010).

In the Last Century

The fundamentals of modern periodization were established in the former USSR. Russian scientists and trainers took it upon themselves to publish literature about the separation of the training process into two periods: a general period, focused on cardio-respiratory fitness, general coordination and athletic capability, and a more specific period focused on the techniques and tactics of the sport. This division predominated in team sports (Issurin, V.B., 2010), and even today we can see the tendency to divide training up in accordance with this method. In the1950s, there were numerous publications in Russia that provided scientific support to this practice. However, the first summary of this research was published by **Matveyev** in 1966, making him the founder of the **theory of sports training.**
Nowadays, training periodization such as "the subdivision of a training season into shorter periods and training cycles" (Issurin, V.B., 2010, p.192) is an indispensable part of the theory of training.

What is Periodization?

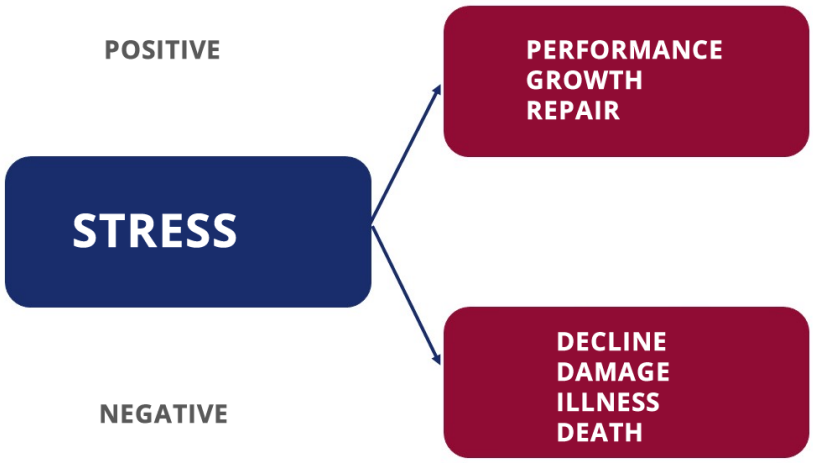
Periodization in strength training refers to the planned changes in the variables of the training program: the order of the exercises, the choice of exercises, the number of reps, the amount of reps per set, the intensity of the training, the volume and number of training sessions per day, so that these modifications aid in increasing the athlete's performance (Fleck, S.J., 2011). The main objectives of periodization are: optimize the athlete's adaptation to brief periods of time (such as a week or a month), as well as long periods (a year, a four-year Olympic cycle or the length of an athletic career). In every case, the aim is to achieve peak performance at a specific moment of the season and avoid plateaus of low athletic performance (Fleck, S.J., 2011).

The Physiological Basis: General Adaptation Syndrome.

In 1936, **Hans Selye** outlined an astonishing new paradigm for his time, publishing an article in which he postulated that, regardless of the nature of the harmful stimulus, the body responds in a stereotyped manner. This reaction represents an attempt by the body to adapt to the new condition it is subjected to, and he named it **General Adaptation Syndrome (GAS)** (Bértola, D., 2010). GAS, according to Selye, consists of three universal stages. The first stage is called the **alarm reaction**, the second is that of **resistance**, and the third is the **exhaustion** stage. If the body is subjected to a load or a "stressor", it produces a partial decrease in its ability to overcome this element, and it enters a state of alarm. If this first stage is survived and the harmful stimulus persists, the body enters a second stage where it stabilizes its functions to virtually normal levels, building a resistance. But if this situation continues as such, the body will enter a third stage of exhaustion. Selye used the term stress (meaning tension, pressure, duress) to define the condition in which the body responds to the harmful agents ("stressors"). GAS suggests that living organisms have the ability to adapt on their own to the environments which surround them (Selye, 1950).

It is important to understand GAS, since it explains the adaptations that occur in the process of strength training. Selye identified two forms of stress: a **beneficial stress** which produces growth, and a **detrimental stress** which results in decay, damage, disease or death (Figure 1.) (As cited in Siff, M.C. & Verkhoshansky, Y. 2004).

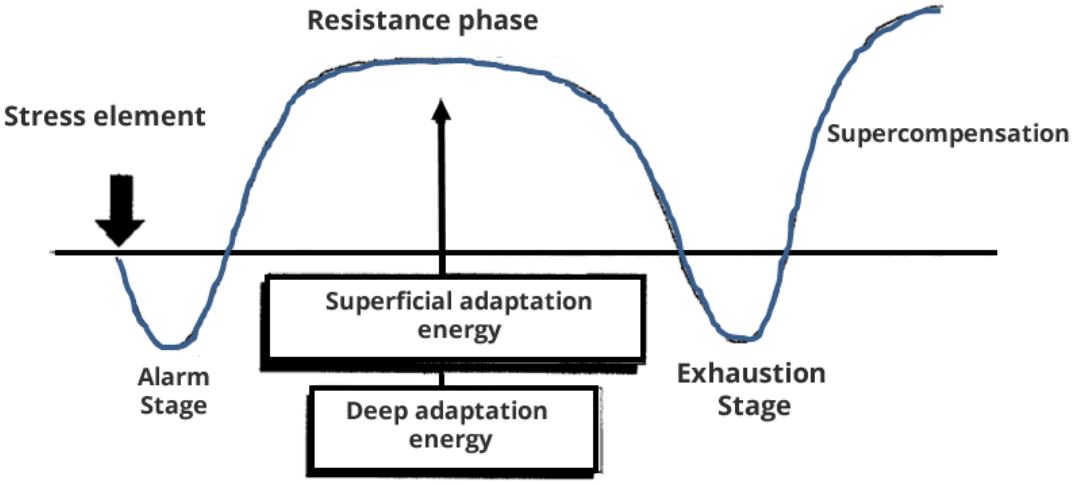
Figure 1: Different Types of Tension and their Possible Consequences According to Selye



Source: Adapted from Siff & Verkhoshansky, (2004). Superentrenamiento, p.105.

An appropriate periodization of strength training will give the individual a harmonious interaction between performance, growth and repair. At the same time, we should be on the lookout for discomfort, aches, and minor injuries in our athletes, since the presence of these is a viable indicator of the beginning stages of detrimental stress (Siff, M. C. and Verkhoshansky, Y., 2004).

Figure 2: Selye's General Adaptation Syndrome Model



Source: Adapted from Siff, M. C., & Verkhoshansky, Y., (2004). Superentrenamiento, p.107.

Principles of Training Periodization:

Progressive Overload Principle

According to Greek mythology, Milo of Croton was the first person to apply the progressive overload principle. To become the strongest man in the world, Milo started picking up and carrying a calf for one full kilometer every day. As the calf grew, Milo became stronger. After some time, the calf had grown into a large bull and Milo was the strongest man in the world at that time, thanks to a long-term progression (Bompa, T. & Buzzichelli, C., 2015). The improvement in performance is a direct result of the quality of the training. From initiation up to elite levels, the load must be increased gradually according to the athlete's physiological and psychological ability. Every drastic change in athletic performance requires a long period of training and adaptation. Just as an athlete's body reacts physiologically, the nervous system, coordination functions and psychological adaptation to deal with new stressors all progress gradually (Bompa, T. & Buzzichelli, C., 2015).

Variety Principle

Contemporary training requires many hours of work from the athlete. The volume and intensity of training are in constant variation, and the exercises are repeated numerous times. To achieve a heightened performance, the player must overcome a threshold of 1,000 hours of training a year (Bompa, T. & Buzzichelli, C., 2015). The monotony and boredom that can be caused by all of this training work become motivational obstacles. On top of this, one must consider the fact that performing the same exercises at the same intensity and volume over a long period of time may cause injuries due to overuse (Kraemer, W. J. y Fleck, S., 2007).

To counteract this, it is generally suggested to alternate variables in order to enrich the training process; some methods for doing this are: alternating exercises, varying the sets, repetitions, the type of equipment being used, the type of muscle action and speed, always taking into the account the time of year and the main objective behind the training.

Individuality Principle

Each athlete is unique and unrepeatable, and, as such, should be treated according to his or her abilities, potential and environment. Trainers will often attempt to apply the training programs of other star athletes on their players, and neglect to consider the needs, experience and characteristics of their own athletes; or worse yet, they subject young athletes to the training plans of much more seasoned players. However, even players with similar performance potential may have different tolerance levels towards training.

The ability to recover is also a differentiating factor among athletes that must be taken into consideration. When a work program is introduced, the athlete's lifestyle must be considered, as well as socio-emotional issues that surround them, as these will influence the ability to adapt to the training.

Specificity Principle

In order to be effective, training must include specific adaptations towards the sport being practiced, whilst considering the fact that the more specific the stimulus, the larger the burden on the musculoskeletal system; thus, more attention must be placed on volume, intensity and recovery from said stimuli.

The Five Laws of Strength Training

According to Bompa and Buzzichelli (2015), there are five laws that cannot be overlooked in strength training to ensure the athlete's adaptation as well as avoid injury. These are:

1) Develop breadth of joint movement:
   - Most of the exercises must be performed in an optimal range of motion in joints such as the hip, knees and ankles. Above all, flexing and plantar dorsiflexion must be emphasized during the first phases of the athletic development.
2) **Develop Tendon Strength:**
   - Misunderstanding the specificity principle or a lack of long-term vision results in trainers neglecting the proper strengthening of tendons and ligaments. Without the anatomical adaptation of tendons, intense training may lead to injuries. Training tendons correctly can lead to their breadth increasing and thus improve their ability to withstand tension and torsions.
3) **Develop Core Strength:**
   - The arms and legs are only as strong as the core (we will elaborate on this in Module Three). An adequate training program must first focus on trunk strengthening before going onto other movements. These muscles act by absorbing the impact of jumps, bounces or plyometric exercises once the body is stabilized and represents the union or transmission of strength between various parts during complex movements.
4) **Develop the Stabilizers:**
   - The muscles that perform primary actions are more efficient if they have strong stabilizers. These contract isometrically to stabilize the joint and allow another body part to perform. Poorly stimulated stabilizers inhibit the capacity of bigger muscles to work.
5) **Train Movements, Not Muscles:**

- The goals of team sports are different from the goals of bodybuilding. Strength training in team sports seeks to improve the athlete's performance in the game and optimize their skills; this is achieved if these tasks can be simulated during training. We know that in-game techniques are complex polyarticular movements that occur, most of the time, in an unexpected fashion.

Solé Fortó (2008) states:

> Periodization divides the season into cycles (one or two), which are then structured into periods. Each period seeks to acquire a type of athletic fitness. Specifically, the **pre-season period** seeks to acquire athletic fitness, while the **competitive** period seeks to maintain optimal fitness; the **transitory** seeks to prevent the relative loss of said fitness. Each period consists of various stages of training, where the burden is regularly applied during the time.
>
> The season is made up of the following stages:
>
> **Pre-season:** Preparation phase which seeks to acquire athletic fitness for a guaranteed start to the competitive calendar. Generally, in team sports, the pre-season is six to eight weeks long.
>
> **Competition or League Stage:** It takes place during the competitive calendar. It consists of one or two matches per week. It seeks to achieve a high stability fitness that, as the match progresses, may evolve into a state of maximum performance. It lasts for between 6 to 9 months.
>
> **Regenerative Stage:** It takes place once the league is finalized, and seeks to help the player recover physically and psychologically. It also has an objective of preventive hygiene, where maintenance and compensation loads are applied. (p. 177).

2.1.2 Linear Periodization vs. Undulating Periodization

Training periodization has proven its effectiveness in athletic performance, in recreational training and in the field of recovery. In a meta-analysis of over 100 studies performed between 1962 and the year 2000, Rhea and Alderman (2004) found that periodized training programs achieve greater strength gains and power than non-periodized programs. Even with similar volume and intensity, the authors discovered that periodized training accomplished greater increases in strength and power than non-periodized training.

Periodized training programs are usually designed in accordance with two very different models: linear and undulating models.

The linear model consists of starting with high volume and low intensity; as the training progresses, the volume decreases and intensity increases in order to maximize the gains in strength and power (Fleck, S., 2011).

These training plans require several months to complete. In a linear program, the periods last four to six weeks in a determined zone; for example, 1 to 6 or 8 to 12 reps per set. Within this type of periodization there are several different stages, each with a specific name and objective: hypertrophy, maximum strength, maximum strength/power and power. Most programs of this kind attempt to achieve a spike in strength gains before entering the power stage (Fleck, S., 2011).

Undulating periodization (also called non-linear) requires constant variations of intensity and volume within cycles of six to ten days of work, in which training protocols for the neuromuscular system are alternated (Kraemer, W. J. and Fleck, S. J., 2007).

In this way, the areas of training vary as the training itself progresses, meaning the number of reps and sets will vary from one session to the next. The simplest pattern to follow in this type of programming utilizes three areas: from 4 to 6, from 8 to 10, and from 12 to 15 rep maximums in a total of three weekly trainings, training each area once a week (Fleck, S. J., 2011).

Seeking to compare strength gains in university students after performing undulating periodizations (UP) or linear periodizations (LP), Rhea, Ball, Phillips and Burkett (2002) divided 20 males aged 21 into two groups, and evaluated them on bench and leg presses. The training consisted in performing three sets of both tested exercises, three times a week, for 12 weeks. The LP group performed 8 reps per set between weeks one and four, 6 repetitions on weeks five to eight, and 4 repetitions on weeks nine to twelve. Meanwhile the UP group alternated its trainings during the twelve weeks in the following manner: 8 repetitions on Mondays, 6 repetitions on Wednesdays, and 4 repetitions on Fridays. After twelve weeks of training, both groups showed significant improvement in strength, though the UP group was clearly the strongest of the two. We plot the results in the following table:

Table 1: Experiment by Rhea et al. (2002).

	Week 1 kg total bench-press	Week 12 kg total bench-press	% of change of bench press week 1-12	Week 1 kg total leg press	Week 12 kg total leg press	% of change of leg press week 1-12
LINEAR	83.41 (± 12.86)	94.55 (± 10.72)	14.4 (± 10.4)	266.82 (± 55.38)	331.36 (± 68.18)	25.7 (± 19.0)
UNDULATING	66.59 (± 19.23)	83.41 (± 20.27)	28.8 (± 19.9)	230.23 (± 65.05)	350.23 (± 80.82)	55.8 (± 22.8)

Source: Adapted from Rhea et al., 2002. S.p

The research studies that compare both of these models generally last between nine and fifteen weeks. Looking at university students, some comparisons show greater strength gains with UP, such as Rhea et al., (2002) and Monteiro et al. (2009), while other comparisons do not show significant differences between both periodizations. In most of the comparisons, the subjects are young men with little or no experience in weight training, such as in the study by Kok, Hamer and Bishop (2009), and Prestes, De Lima, Frollini, Donatto, and Conte (2009), which is why more data is required with more experienced athletes to obtain more conclusive information. Only one study performed with experienced athletes (American football players from US universities) (Hoffman et al., 2009) indicated that UP is equal or possibly more effective than LP when it comes to maximizing strength gains.

Muscle power, weight and body composition also do not seem to show any significant differences after performing both periodizations (Rhea et al., 2002; Hoffman et al., 2009; Kok et al., 2009; Monteiro et al., 2009; Prestes et al., 2009).

Flexible Undulating Periodization

This is a relatively new method of periodization that uses the non-linear model, but allows for changes in the training based on the athlete's predisposition to train in a specific area. The decision to change the training from one specific area to another is based in various types of data. For example, performing a test prior to training, such as a vertical jump, a long jump and/or throwing a medicine ball a few minutes before starting work can help determine how prepared a player is to train a specific area. The first sets of the first exercises can also be monitored to determine the area that will be worked on during the session (Fleck, S. J., 2011).

For example, if during a vertical jump prior to the start of training the player is unable to reach at least 90% of their previous record, it may be that they are in a state of fatigue. The same can be said if - at the start of the session - the athlete performs 7 reps of an exercise with the same weight with which they usually perform 10 reps. Fatigue and other physiological factors such as DOMS (delayed onset muscle soreness) or psychological stress can be key factors in the inability of an athlete to perform in a state of peak disposition.

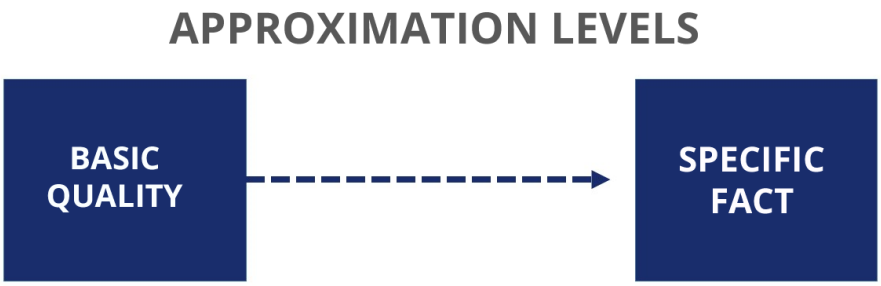
Whatever the cause, if a moderate-intensity training and moderate-volume training are scheduled (for instance, four sets of 10 to 12 reps) and the athlete is not favorably disposed, the training area should be replaced by a different area (for example, three sets of 12 to 15 reps). It is also possible to change in the opposite direction; for instance, if a low-intensity and high-volume training is scheduled and during the prior tests the athlete reaches 100% in their vertical jump, this indicates that it can be changed to a high-intensity area of 4 to 6 reps, since there are no signs of fatigue and the athlete is ready to perform a high-intensity training (Kraemer, W.J. & Fleck, S.J., 2007).

Shimano et al. (2006) performed research with a group of university soccer players using flexible UP during a 16-week season. The strength sessions were modified based on the subjective evaluation of the coaches and the heart rate during technical and tactical trainings and matches. Not only did the players maintain their values in vertical jumping, short sprints and oxygen consumption during the entire season, but they also had significant increases in lean body mass and muscle power (17% in upper body and 11% in jumps with load).

2.1.3 Levels of Approximation (adapted from Seirul-lo, 1994)

If we require the player to apply a specific amount of strength on a particular motor act (for example, a handball throw), they must have gone through several stages prior to training, which we will refer to as "levels of approximation".

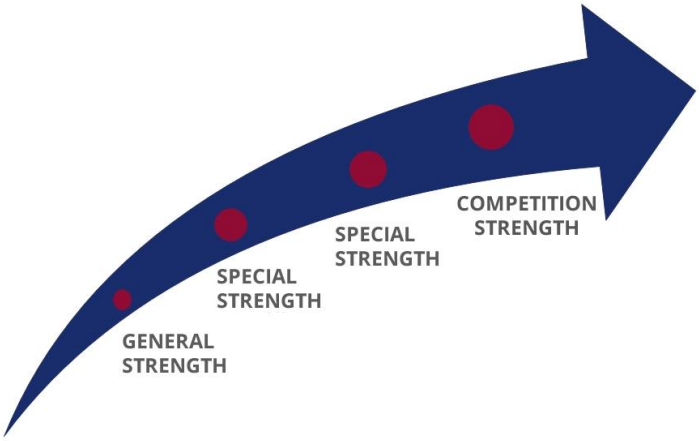
Figure 3: Levels of Approximation



Source: Adapted from Seirul-lo, 1994. p. 14.

According to Seirul-lo (1994), there are four levels of approximation that determine the specificity of a task in relation to the particular game action; these will allow us to program and organize contents during planning. These are: **general strength, directed strength, special strength, and competition strength.**

Figure 4: Four Levels of Approximation



Source: Adapted from Seirul-lo, 1994. p. 14

In each level, we can establish three strength categories corresponding to the specific sport; in the case of handball or basketball:

- **Fighting or racing strength:** fighting for a position, a change of direction, or a one-on-one.
- **Jumping strength:** Rebounds, throws, layups or blocking an opponent's shot.
- **Throwing and passing strength:** With one hand, two hands, different techniques.

On the other hand, it is very important to distinguish three types of exercises when designing a task.

- **Basic or Fundamental:** This is of great importance since it is the jumping-off point for all subsequent work.
- **Application or assimilation:** attempts to transfer the fundamental exercise to the technical action to be optimized.
- **Complementary of Compensational:** This attempts to alleviate or assuage the aggressiveness of the previous exercises, which are frequently damaging to the athlete's osteoarticular system.

The proper programming of the levels of approximation allows the coach to:

  - Develop coordination aspects of a player's actions more effectively.
  - Reach the best possible shape and maintain it for longer.
  - Localize the areas of inspection and evaluation of the player's performance.

First level: General strength.

The athletes work on all kinds of strength exercises that are not necessarily specific to the sport in question.

This stage is configured as follows:

Table 2: Characteristics of the First Level, General Strength

• It is developed analytically based on the muscle groups that perform a specific motor action and collaborate at the nearest joints.
• The conditions of muscle resistance are varied.
• Body postures are not similar to the game actions.
• Speed conditions are varied, but structurally similar to the motor pattern it attempts to approximate.
• The overloads must be different, but always greater than the motor pattern in a way that allows for strength increases in that muscle group.
• The instruments used shall be varied and different according to the specific game.
• The tasks must involve a high value of self-control and little to no tactical component.
• There is an unspecific coordination component.

Source: Adapted from Seirul-lo (1994) p. 16

Second level: Directed strength

It allows the improvement of the technical-tactical action through an increase in strength. The strength work continues, but more closely resembles the game with a relative transfer.

Table 3: Second Level, Directed Strength

• Global development of kinetic chains that constitute each group of motions, throws, jumps, etc.
• The resistance conditions are more in line with, or more complimentary of, the game specifics.
• The body movements of the person performing the movement look more like the movements in the game.
• Speed conditions are very close to the specific ones.
• The overload must be greater but a lot closer to the game action to allow further increase of speed.
• The instruments may be varied but more similar to the specific ones, to stimulate points of contact.
• Self-control is decreased, while control via exteroception increases and tactical contact elements are introduced.
• Self-control is decreased, while control via exteroception increases and basic tactical elements are introduced.
• Coordination components align with the specific motor function.

Source: Adapted from Seirul-lo, 1994. p. 17.

Third level: Special strength

The work becomes more attuned to the characteristics of the sport in question. In basketball, for example, explosive strength when catching a rebound or doing a lay up. The work must simulate the game action in a coordinated fashion.

Table 4: Third Level, Special Strength

• Global quality development, placing emphasis on the specific kinetic chain of each motor pattern.
• Resistance conditions are identical, or as close as possible.
• Body positions are equal and difficult in comparison to the global and segmented positions, as a result of the previous tasks.
• Speed conditions identical or, if possible, greater.
• Equal or lesser overload in relation to speed.
• Instruments identical in design and size that favor the points of contact.
• High self-control and extremely high exteroceptive requirements with complex tactical elements.
• The coordination component must be greater than the needs of the specific task.

Source: Adapted from Seirul-lo, 1994. p. 18.

Fourth level: Competition strength

This level must be developed simultaneously by the physical trainer and the coach, since it involves tactical components. They are real-life or simulated exercises meant to repeat game motor patterns where strength plays a principal role. The load to be lifted (for instance, a ball, a partner or opponent) must be the same as in competition.

> In situations of "simulated" real play, a parameter of said play may go through hypertrophy when trying to put emphasis on a specific sequence in which strength is needed to resolve it under the established conditions. Throwing only from "X distance puts emphasis on the strength manifestation for the throw, and if this is done in a real game simulation it is considered to be a competitive exercise to improve this quality. We must keep in mind that these exercises can improve strength substantially on their own, but result in stagnation in quality improvement when they are the only exercises being practiced. Furthermore, the maintenance and level control reached through not just an entire season, but through the years of the athlete's career, is of great difficulty. Therefore, the competitive exercises, which are often performed "inconsistently" by some trainers, must be taken into consideration in the assessment of strength training, and must be proportionally included with exercises from the third level, which are the closest transporters of strength capacity from origin, in general exercises. (Seirul-lo, 1994, p. 19).

More recently, Schelling (2009) proposed that the levels of approximation adapt to a new structure:

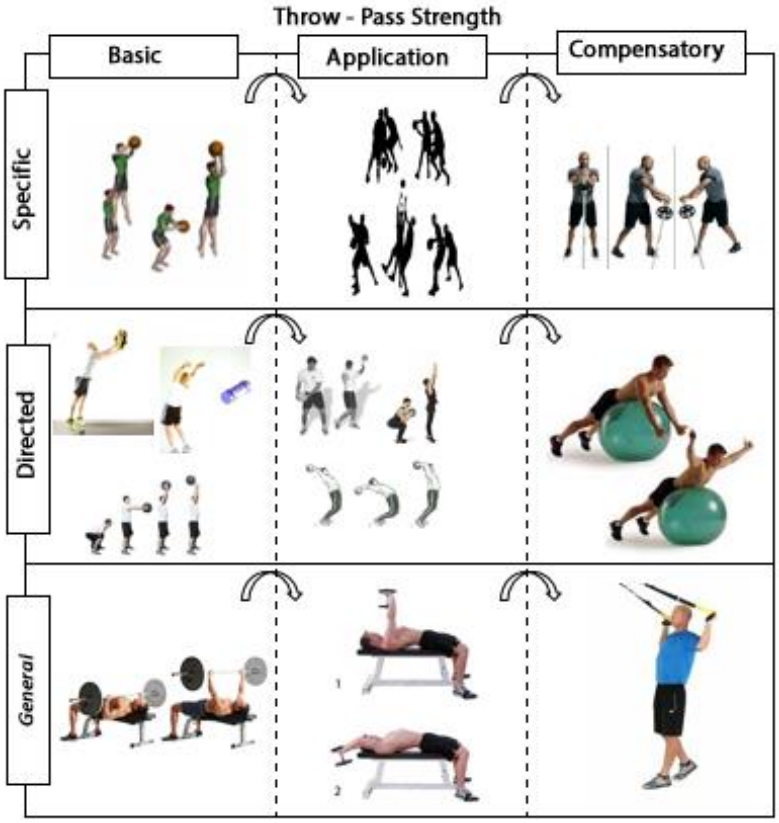
Table 5: Schelling's (2009) Levels of Approximation

	Guidance	Approximation Level	Methodology			
Cognitive Functional	Competitive	Level V (Actual Game)	**Actual Game** With or without rewarding content or concept	Group track	Track sessionsk	Progress to developing a game element from the physical condition to the in-game situation
	Special	Level IV (small groups)	**Technical element + Decision-making** Define possible decisions beforehand.			
	Directed	Level III (technical)	**Training session (with/without ball)** Without decision-making (or simple)	Individual track		
		Level II (physical - technical)	**Same as technical** motion Small overloads (weights-elastics)	Sesiones Físicas (Pista o no)		
Conditional Structural	General	Level II (physical - technical)	Similar to technical motion High load			
		Level 0 + (Guided)	Working the muscles implied in the motion Without similarities in the movement			
		Level 0- (Not guided)	Working the muscles not implied in the motion omplementary / compensatory			

Source: Adapted from Schelling, 2009. p. 20.

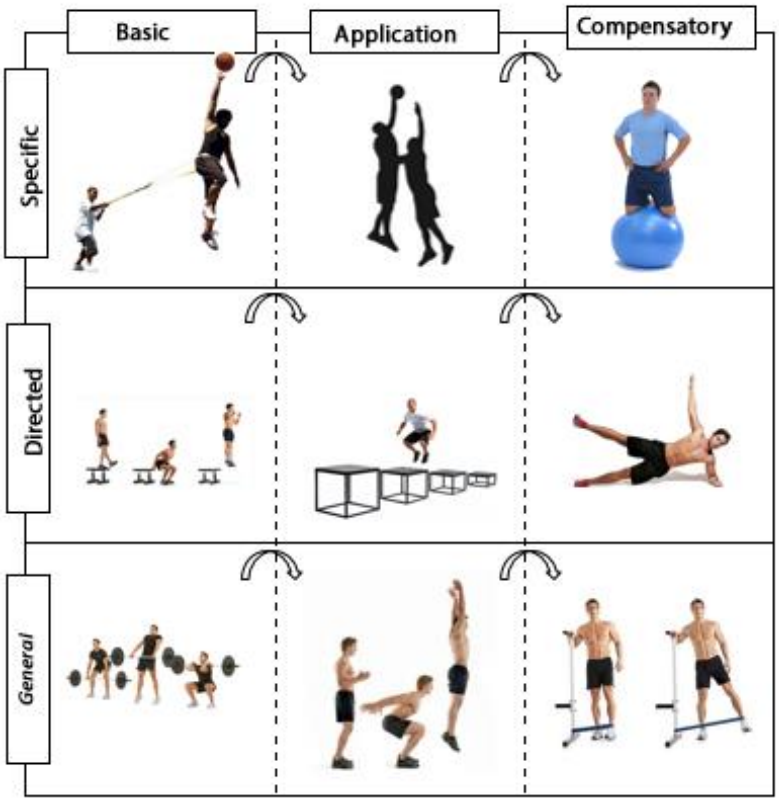
2.1.4 Applied Example of Levels of Approximation (Basketball)

Figure 5: Strength of Throw-Pass



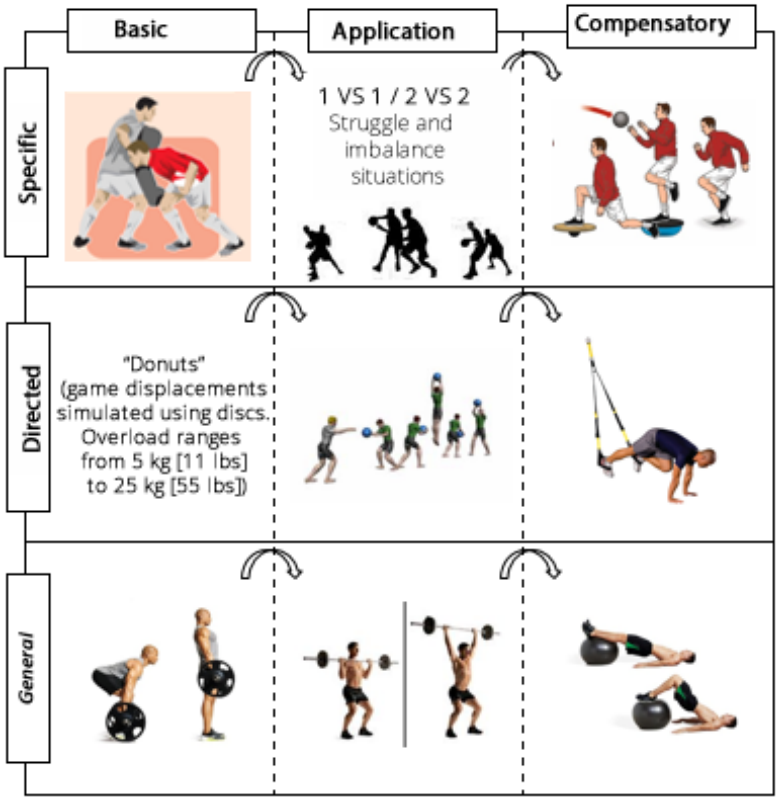
Source: Prepared by the author based on Seirul-lo, 1990, p. 31-35

Figure 6: Strength of Jump



Source: Prepared by the author based on Seirul-lo, 1990, p. 31-35

Figure 7: Fighting strength



Source: Prepared by the author based on Seirul-lo, 1990, p. 31-35

To understand this proposition a little better, you will find this video focusing on handball useful: https://goo.gl/8zwduq (Jordi Cañadas, 2014)