2.2 Training Methods

2.2.1 Machines vs. Free Weights

In training for fitness and quality of life, we can say that using machines or other free weights (such as bars, discs, kettle bells or unstable methods such as the physioball or suspension straps) are not inherently superior to each other. Both methods have their pros and cons. For example, free weights are affordable, portable and easy to obtain in any commercial area; they can be carried in a simple bag and transported anywhere to be used prior to training. Meanwhile, a gym machine offers a specific resistance that allows the user to focus on technical execution and perform simple movements; while on the other hand, they take up a lot of space and cannot be transported.

The main difference between the two training methods is that, when using free weights, the individual is able to move in a three-dimensional plane: forwards, backwards, horizontally and vertically. This is very important since it allows the athlete to mimic the movements of the game. Also, not only do they involve more muscle mass, but the athlete must also work to stabilize their own body while fighting resistance. However, the risk of injury increases if the right technique is not applied.

Machines, meanwhile, are fixed in place; this allows the individual to move in one or two planes at most. That is why using them exclusively may lead to a lack of functional adaptation. This leads to a high risk of injury as a result of the lack of use of stabilizing muscles, which are ignored when using this equipment in favor of stimulating the bigger muscle groups and increasing mobilized weight.

Though the market for machines has evolved notably in the last 20 years, most gyms still feature variable overload machines, where the load is increased by adding or removing weight plates, that generally weigh between 5 and 10 kg each. These machines are built in a standardized way, where the manufacturers attempt to satisfy the demands of a public that is more geared towards physical fitness training than sports training (Dappa, D, 2000).
The following advantages and disadvantages are associated with using this kind of equipment.

Advantages of Using Variable Resistance Machines

1) They are a great way to train specific muscle groups in an isolated manner.
2) They are safer for an athlete's health than using free weights.

3) They simplify organization and distribution of space in group training.
4) It is very easy to increase or decrease the load, which shortens training times.

Disadvantages of Using Variable Resistance Machines

1) Displacement of the load occurs in a pre-determined and stable range. In team sports, motor actions are variable and unstable.
2) It works on simple motor actions that have little to do with the complex technical movements in team sports.
3) The speeds of execution are relatively slow, which hampers high power production.
4) Production is geared towards satisfying the demands of a "average" market, which means that taller athletes such as volleyball or basketball players, as well as shorter athletes (such as those that partake in judo, wrestling, boxing) are often not able to use these machines.
5) Often, a load increase is too high a percentage for the athlete; since it has fixed increases (plates of 5 to 10 kg), in some cases athletes are unable to lift the increased load, which generally occurs with beginner female athletes who cannot lift a lot of weight.
6) Many times, the total amount of weight that the machine offers for mobilization is not a sufficient stimulus for very strong athletes.
7) Often, the market price is too high and they do not represent an increase in the quality of training, making purchase unproductive.

It is important to keep in mind that this analysis is in the context of team sports. If the main reason for training was health and quality of life, these assessments would be significantly different.

It is worth pointing out that in order to decide which methods to use, one must analyze the cost and benefit of each method and keep a balanced point of view, focused on the end goal being pursued with training. While free weights should be the cornerstone for any strength training program, machines may be a great support that can aid in the development of certain muscle groups in need of extra stimulus.

2.2.2 Weightlifting Derivatives

Weightlifting is one of the classic sports of the Olympic Games. It is competed in two different modes: **snatch** and **clean and jerk**. In the snatch, the athlete raises the bar high above his head in a single movement at a very quick speed (1.6 - 1.7 m/s) (Cappa, 2000). In this exercise, weight lifters are able to move very heavy loads that represent around 2.4 times their own body weight in the lightweight category (54

kg or less) and 2.17 times in the heavyweight categories (100 kg or more). The heavy loads plus the incredibly high speeds of execution make this an ideal movement to develop high levels of muscle power.

The second exercise is the clean and jerk. In this exercise, the bar is also lifted above the head; not in one, but in two movements. In the first movement, the bar is taken from the ground up to the shoulders and is then considered *clean*, while in the second movement the bar is moved from the shoulders to above the head. In this exercise, a weightlifter can lift up to 2.9 times his body weight in the lightweight categories (54 kg or less) and 2.17 times in the heavyweight categories (100 kg or more) (Cappa, D., 2000).

These kinds of movements are known for being the activities with the highest levels of power achieved by a human being in any strength exercises. For example, a 100 kg lifter can produce 3,000 watts of pure power, compared to the 1,100 watts that is generated in a squat (Garhammer, J., 1993). Due to the capacity of these exercises to generate enormous levels of power, as well as their movement patterns and velocity which are relatively similar to sporting activities, these exercises are considered to be one of the best ways to increase athletic performance (Stone, 1993).

Table 6: Maximum Power Generated by Various Exercises

Maximum Power Generated by Various Exercises		
Exercise	Absolute power in watts	
	Male - 100 kg	Female - 75 kg
2nd time	5400	2600
Clean	3000	1750
Snatch	2950	1750
Squat	1100	
Dead lift	1100	
Bench press	300	

Source: Adapted from Haff, Whitley & Potteiger, 2001.

The ideal loads to maximize power production in this type of exercises appear to be above 80% of a rep maximum (RM) (Garhammer, J., 1993); this heightened percentage is inherent to the nature of the exercise (high speed and great strength produced).

Figure 8: Snatch

Source: adapted from Böttcher & Deutscher, 2004, as cited in Zawieja-Koch, 2005, p. 9.

According to the International Federation rules and regulations, when performing a snatch, the athlete stands facing the bar, gripping it with palms down and flexing both knees. From this position, the bar is pulled in a single movement from the floor until the maximum extension of both arms over the head. During the entire process, the bar is kept very close to the body and can be slid over the thighs. Only the athlete's feet may touch the platform through the entire movement. The weight, once it is lifted, must remain static; that is to say, held up with both arms and legs stretched out and feet lined up in parallel. Once the referee gives the signal, the athlete may drop the bar onto the competition platform.

In the following video you can observe what we have described here: https://goo.gl/0bNLEp (Frank Rothwell, 2015)

Meanwhile, the clean and jerk is split up into two parts: the clean and the jerk. In the first part (the clean), the athlete stands facing the bar, gripping it with palms down (in a more closed angle than in the snatch) and knees well bent. The weight is then lifted in one single movement from the platform up to the shoulders, and may be accompanied by a jump. During this continuous movement, the bar must not touch the chest before it gets to its final position, generally on the clavicle or chest, with arms fully bent. Then, the athlete's feet must return to their initial position before beginning the second part. The athlete must complete the first part with his feet in parallel and legs completely extended, parallel to the trunk and the bar.

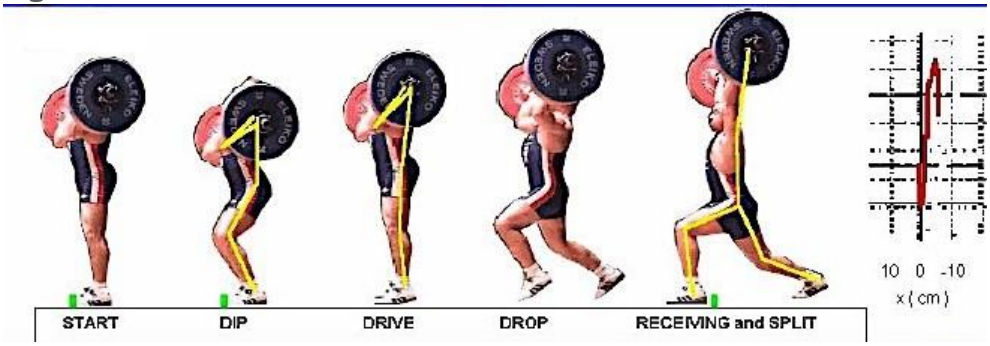
Figure 9: Clean

Source: adapted from Böttcher & Deutscher, 2004, as cited in Zawieja-Koch, 2005, p. 9.

In the second part of this movement, the athlete flexes and extends their legs energetically while raising the bar with their arms; all of this occurs in a single movement until reaching maximum arm extension. After this,

the athlete must return to the same line parallel to the plane of the the trunk and bar with legs completely extended, waiting for the referee to signal that they can lay down the bar.

Figure 10: Clean and Jerk

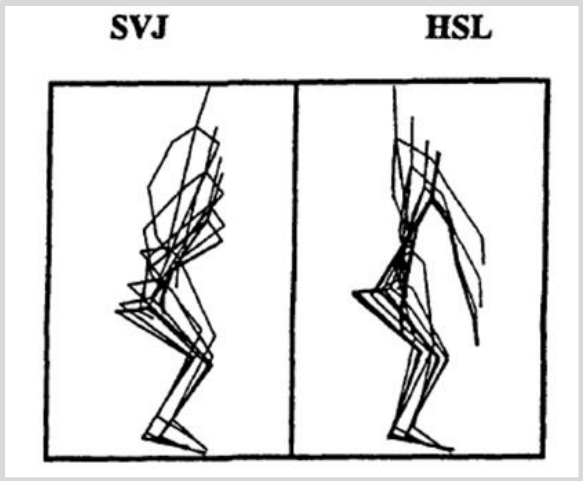


Source: Adapted from Böttcher and Deutscher, 2004, p. 9.

In the following video you can observe what we have described here: https://goo.gl/i0TF2G (kettlebellsport, 2013)

From a practical standpoint, using complete lifts (from the ground) in the context of sports training does have some complications, which is why variations or derivatives are used to maximize power. In these kinds of exercises, you begin with a hanging bar, that is to say, on the thighs, above or below the knee (depending on the technique), which requires less amplitude of movement. It has been proven that the use of these kind of exercises improves performance significantly in jumps as well as short distance springs (20 yards or 18.2 meters), but not as much for changes of direction.
The training programs that incorporate variations of the snatch and the clean and jerk improve their capacity for vertical jumps between 2.8% and 9% (MacKenzie, S.J., Lavers, R.J., & Wallace, B., 2014). The reason for this improvement is based on the kinematic similarity between performing a vertical jump and these kind of exercises, as demonstrated by Canavan (1996). In the following figure you can observe what we have just described:

Figure 11: Similarity in Movement of Body Segments during a Squat Jump Compared to a Power Snatch



Source: Canavan, Garrett, & Armstrong, 1996 p. 130.

On the left side of the picture we see the movement of the body segments in a squat jump, and on the right, a power snatch.

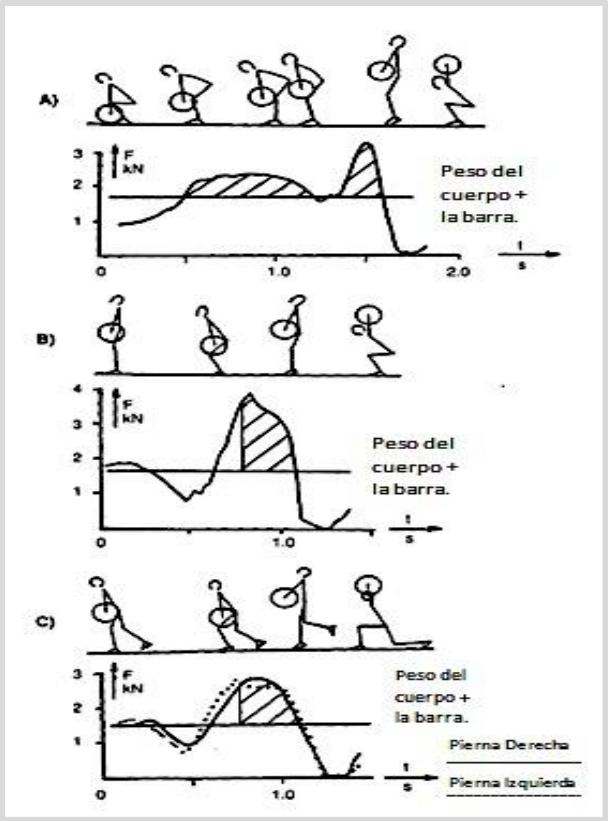
It is recommended to use weightlifting derivatives in training programs due to the following reasons:

- They are exercises that generate a tremendous amount of muscle power.
- The technique is simpler than the full motor pattern, which is why athletes who are relatively inexperienced in overload training can learn it more easily.
- By not raising the bar from the ground, we can avoid the slower phase of the exercise and perform the phase that generates more power.
- These exercises closely resemble powerful athletic motor patterns such as a counter movement jump (CMJ).
- For tall athletes with a wide wingspan such as volleyball or basketball players, these exercises allow for an easy adaptation and protection of their joints.

In the following figure, we see the ground reaction force and a snatch's development time. In image A) we can see a traditional snatch with two legs, from the ground with 80 kg; in image B) a hang snatch with two legs and 85 kg; and in C) a hang snatch with one leg and 65 kg.

It is interesting to note the possibility of realizing unilateral variances as a method to improve the power production in these types of motor patterns that characterize team sports, such as, for example, layups in basketball. As seen in variant C), the athlete may develop, with one leg, much more than than just 50% of what they can perform with both.

Figure 13: Comparison of Ground Reaction Force and Development Time in 3 Different Types of Snatch (from the floor, hanging, and hanging with one leg)



Source: (Bartonietz 1996, p. 30).

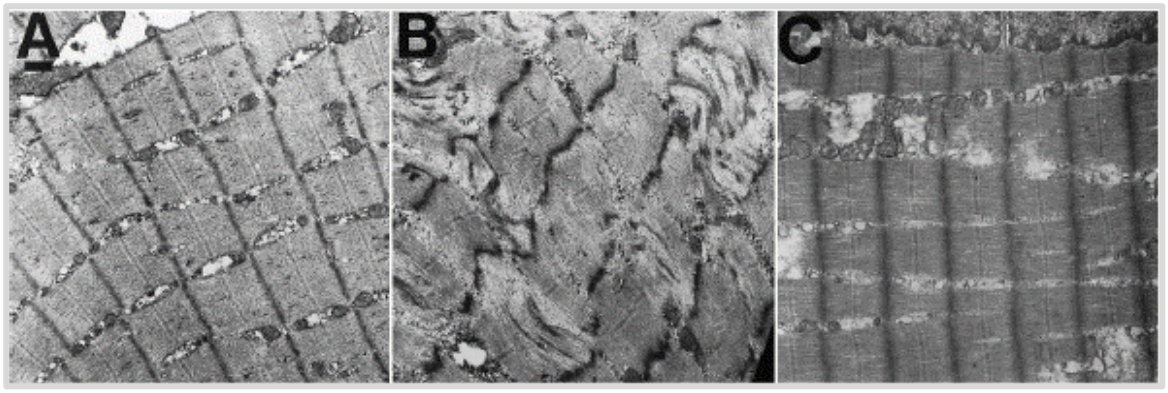
2.2.3 Eccentric Work

Eccentric work, more accurately called eccentric overload work, is one of the great innovations of sports training of the last 20 years. Its efficiency has been proven not only in the field of sports performance, but also in injury prevention and rehabilitation of various pathologies such as Achilles or patellar tendinitis (Tous Fajardo, J. 2010). Eccentric actions are capable of producing more strength than concentric actions since the crossed bridges generated by the actin filaments and myosin use the elastic energy stored due to stretching (Norstrand, 2008) and in this way, mechanical efficiency is higher and metabolic cost is lower (Enoka, R.M., 1996).

This mechanism of tension over crossed bridges, when the fibers are elongated, causes disruptions in the myotendinous junctions, contributing to damaging muscle tissue and generating pain and inflammation (Hortobagyi, et al., 1998). In the next figure, we see longitudinal cuts on the vastis lateralis muscle before (A), two days after (B), and seven days after (C) performing ten sets of 10 repetitions of an eccentric exercise for quadriceps. Image B shows the disarray of the

filaments and extensive damage, and in C the full recovery the following week.

Figure 14: Longitudinal Cuts on the Vastis Lateral Muscle



Source: Hortobagyi et al., 1998, p. 496.

The utilization of predominantly eccentric exercises in the field of sports is of great importance. In muscle tears, it is accepted that the tearing mechanism is produced when the contracted muscle stretches over its limits, meaning it cannot sustain a specific tension of elongation (Noonan, T. & Garrett, W.E., 1999), to which eccentric exercises provide a protective effect known as the repeated bout effect. This phenomenon occurs after a session of eccentric work and after its full recovery takes place, the repetition of the same stimulus only causes minimal muscle damage, meaning that it increases the tolerance threshold for muscles to process that load and produces a protective effect that makes the muscle less vulnerable to tears (Tous Fajardo, J., 2010), an effect that could last several months.

Although the exact mechanisms of this preventive phenomenon generated through eccentric work training are not fully known, there are three theories that attempt to explain it:

- **Neural Theory**: according to this theory, the initial damage is the result of high intensity of the stimulus on a relatively small number of quick muscle fibers. After this period, an increase in the activation of motor units towards the same stimulus can be observed.
- **Connective Tissue Theory:** This hypothesis states that the damage is produced after an eccentric work session at the level of non-contractile connective tissue, thus, it becomes injured and the myofibril integrity is lost. It is suggested that the later remodeling of the connective tissue filaments has a preventive effect.
- **Cellular Theory:** This theory proposes that the muscle damage is caused by micro-rests in the sarcomere, caused by a repetition of eccentric actions and that after a period of adaptation, there is an increase in the number of connected sarcomeres, which would

impede further damage (McHigh, M. P. Connolly, D.A., Eston, R. G. & Gleim, G. W., 1999).

To program these eccentric exercises in the training process we must be aware of not just the benefits, but the setbacks they can cause. We can synthesize the negative aspects of the acute response after this type of stimulus in the following way:

- Immediately after performing them, muscle rigidity increases and, consequently, flexibility is decreased (Cleak, M. J., 1992).
- They generate delayed onset muscle soreness (DOMS) (Nosaka, K. & Newton, M., 2002).
- Muscle micro-ruptures of Z discs, sarcomeres, titin and nebulin. This causes muscle enzymes to be released into the bloodstream, stimulating an inflammatory response that can last up to a week (Marqueste, T. et al., 2004).
- Alteration of the sensory organ response with its corresponding decrease in motor control (neuromuscular spindles and Golgi tendon organs in the joints) (Marqueste et al., 2004).

To synthesize the positive effect of applying eccentric stimuli, apart from the protective muscle effect we can also consider that:

- They increase strength significantly, generating less fatigue than concentric actions (Hortobagyi et al., 1998).
- There is more crossed adaptation (this is because, on a neural level, the application of stimulus produces an adaptation in the contralateral limb) than concentric actions (Hortobagyi et al, 1998).
- They increase synthesis and remodeling of type I collagen in tendons, which is what makes it into an effective rehabilitation agent for tendinopathy (Langberg et al., 2007).

Eccentric Overload Training Methods:

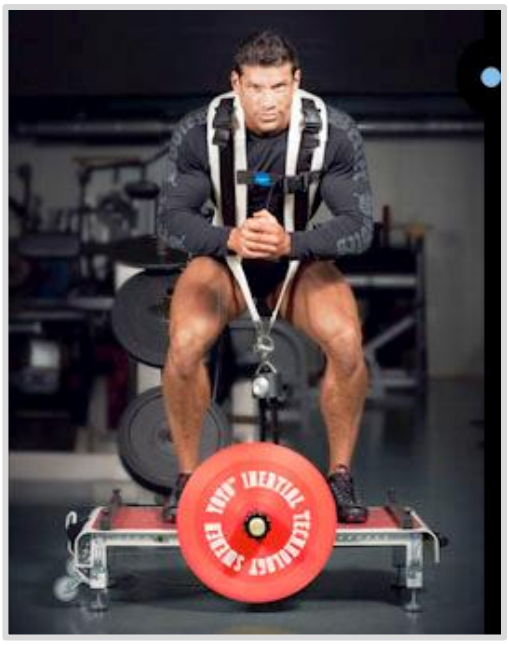
Isoinertial Machines (Conical Pulleys and Yo-Yo Machines) This type of technology was created to alleviate, in astronauts, the effects of physical inactivity caused by the micro gravity environment (Norrbrand, L., 2008). The conical pulley, also known as the Versa Pulley, is a cone attached to a fixed inertia wheel that can have weights added to it to alter the moment of inertia. The cone is tied to a rope that, once you pull on it, creates a variable inertia during the breadth of movement and with it a greater resistance in the narrower part of the cone. The direction of the traction of the rope can be applied in any one of the three dimensions, which allows for the possibility of developing complex, specific and nearly unlimited movements (Tous Fajardo, J., 2010).

Figure 15: Conical Pulley

Source: [Untitled image of conical pulley]. (Undated). Retrieved from: https://goo.gl/LKsc2k

When the Yo-Yo machine is used, the disc and the inertia cone go together towards a structure. Unlike the pulley, a cord is not used, but a transmission strap that is connected to the structure's axis that goes along with the disc, while the other end of the strap is attached to a piece that the individual wears (belt, jacket, etc.), through which it exerts traction. When the athlete performs a concentric action by pulling the strap, the wheel turns, and it does not stop once it completes its trajectory. This is due to its inertia, which causes the strap to recede and creates a strong pull on the person in the opposite direction to which they pulled; in this way, the individual creates a resistance that is able to slow the wheel, until it depletes its previously pent-up kinetic energy and stops completely. Given that this eccentric action is of lesser angular displacement than the concentric action and having equal energy in both directions, an overload is generated due to the superior eccentric torque (Tous Fajardo, 2010).

Figure 16: Yo-Yo Machine



Source: [Untitled image of the Yo-Yo machine] (undated) Retrieved from: http://goo.gl/GLXIbV

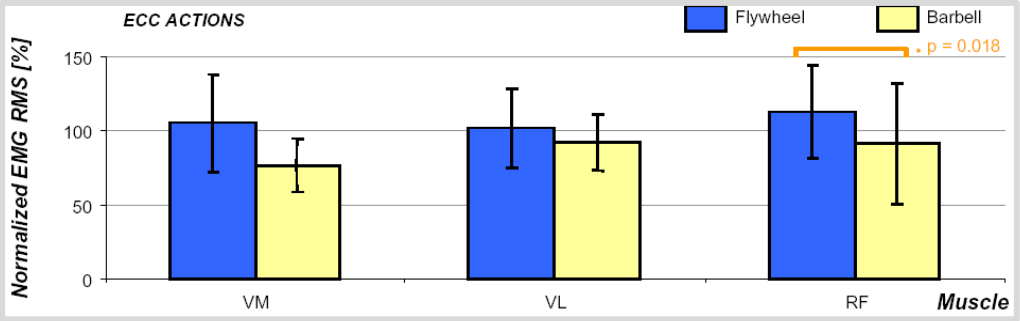
The difference between both isoinertial mechanisms is that the conical pulley can develop very high eccentric speeds with moderate levels of strength, while the Yo-Yo machine is capable of producing higher levels of strength but lower speeds (Tous Fajardo, J., 2006).

Tous-Fajardo, Norrbrand, Pozzo and Tesch (2006) compared the electric activation of quadriceps in subjects performing squats with a bar and squats using an isoinertial device. The authors found a higher activation of the rectus femoris in both the concentric and the eccentric phases while using the Yo-Yo (see following figures) than performing traditional squats. This can be an excellent resource, especially in subjects with a weak trunk that are unable to tolerate heavy loads in their upper body. Identical results were found in studies looking at the activation of the hamstring (Tous Fajardo et al., 2006), which means that isoinertial machines are an effective method to prevent injury in this muscle group.

Figure 17: Squat with an Isoinertial Device vs. Squat with an Olympic Bar

Source: Tous Fajardo et al., 2006, p. 8.

Figure 18: Electromyography (EMG) isoinertial squat (in blue) vs. bar squat (in yellow)



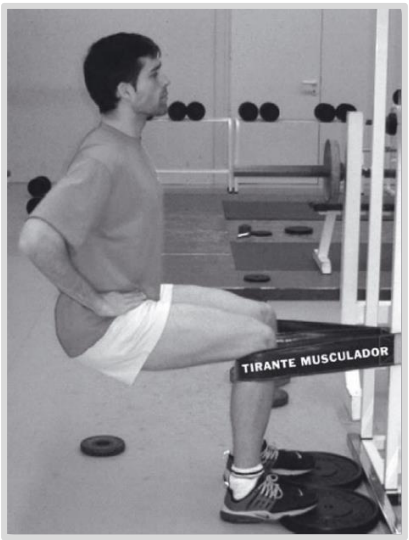
Source: Tous Fajardo et al., 2006, p. 9

We can see in this figure the comparison between the values of electromyographic activation in the eccentric phase (ECC) of a squat using a Yo-Yo machine (blue-colored bars) or performing a traditional squat with a bar (yellow-colored bars) for three different muscle groups (VM: vastus medialis, VL: vastus lateralis, RF: rectus femoris). Significant differences can be observed in all of the muscles analyzed, in favor of the Yo-Yo machine.

Watch the following instructional video: https://goo.gl/kxuz2J (Inerxial, 2013)

1) The muscle flexor or Russian belt is a strap made of flexible material with ends which have loops to place on legs or other body parts.

Figure 19: Muscle Flexor or Russian Belt



Source: Da Silva et al., 2005, p. 46.

Figure 20: Muscle Flexor or Russian Belt

Source: [Untitled image of muscle flexor or Russian belt]. (Undated). Retrieved from: http://goo.gl/oDvP8c

With relative safety and without any major risks to the athlete, the use of a strap allows two types of muscle stimuli: on one hand, the execution of isometric or static actions in stretching, and in the other, dynamic actions in stretching (such as eccentric overload).

Table 7 analyzes the results obtained from the myoelectric activity for four different exercises involving the muscles that make up the quadriceps. the percentage of activation comparing it to the performance of one squat with flexor using 20 kg is shown in parenthesis. It is very important to point out that performing squats with 150 kg on the rectus femoris is only equivalent to activating 84% and 64% in concentric and eccentric phases respectively.

Table 7: Comparison of Electric Activity of the Quadriceps for Exercises with Muscle Flexor, Leg Extension and a Classic Squat

Exercise	Muscle (uV signal) Difference in parenthesis BELT-20 kg)			Phase of muscular action
	Vastus medialis	Vastus lateralis	Rectus Femoris	
Muscle belt squat Quadriceps (0 kg [0 lbs])	252 (92) 379 (107)	153 (77) 243 (84)	202 (81) 236 (83)	Eccentric Concentric
Muscle belt squat Quadriceps (20kg [44 lbs])	275 354	198 288	248 284	Eccentric Concentric
Leg extensions 75 kg [165 lbs] (CKC machine)	188 (68) 249 (70)	164(83) 217 (75)	177(71) 179 (63)	Eccentric Concentric
Classic squat with 150 kg [330 lbs])	308 (112) 369 (104)	202 (102) 228(79)	209 (84) 182 (64)	Eccentric Concentric

Source: González de Suso, J., 2010, p. 3.

Among the most important benefits of the use of this strap we have the following:

I. It allows for eccentric muscle action without any major risks, in a gradual, progressive and controlled way.

II. By creating less shearing force than other exercises, it becomes a safer alternative for articulations.
III. It is an affordable option for training with large groups of players, since it is a simple instrument and if you have more than one, it will allow for better time management in large teams.
IV. It is effective in the prevention of biarticular breakage and tendinopathy.
V. It can be used almost anywhere, as long as the floor is not very slippery and the strap can be anchored to a post.

2) **Utilization of one's own body weight and/or with the help of a partner:** This is an effective method when working with large groups, or when we lack the economic means to acquire machines, or it would be difficult to move them.

This group includes exercises such as the Nordic curl, which has been successfully introduced into some training programs geared towards strength improvement and decreasing injuries, although it has been criticized for its aggressiveness.

Squats on inclined planes have also proven to be effective in the rehabilitation of tendinopathy and knee strength extension programs.

Finally, although there are no studies as yet in this area, it is possible to use a partner's resistance in playful ways, implementing exercises that aim to produce eccentric overload.

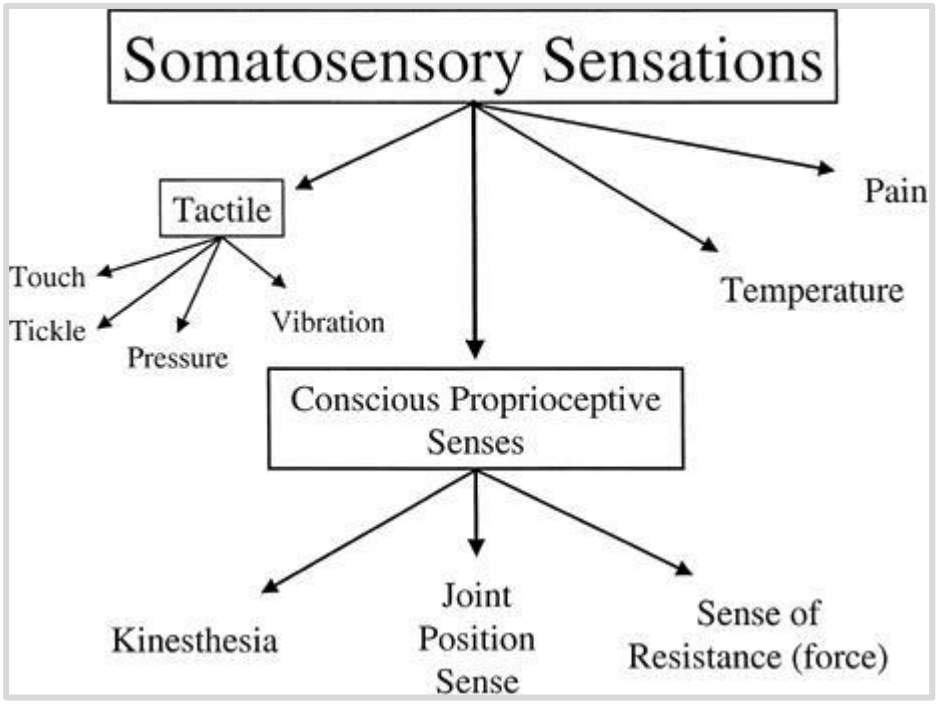
2.2.4 Unstable Methods

Equilibrium and stability training currently occupy an essential role in athletic performance management and injury prevention (Behm, D.G. & Anderson, K. G., 2006). There are various methodologies and exercises that implement various devices for proprioceptive work. In 1906, Sherrington defined proprioception as "the culmination of all the neuronal afferences originating in joint, sinewy, muscle and deep tissue proprioceptors" (as cited in Romero, 2010, p. 169). Scientific evidence indicates that this type of training improves muscle strength, coordination and equilibrium (Behm, D., Drinkwater, E. Willardson, J., & Crowley, P., 2010).

The athlete's central nervous system (CNS) gets the necessary information from the somatosensory system (also known as the proprioceptive system or PS), from the vestibular system and the visual system to control movements. The sensations of proprioception are those that have to do with the body's physical state, the sensations of movement, of pressure at the bottom of your feet and even of

equilibrium. These sensations are felt through specific mechanoreceptors in the skin, muscles, ligaments and tendons. They can perceive pressure, vibrations, sense of position of an articulation and kinesthesia. The importance of proprioception is unquestionable, since it helps to prevent abnormal articulation movements both in positions of extreme tension as well as when flexing. Its prophylactic effect in injury prevention is beyond any doubt, although its contribution to complex movement coordination is also very valuable (Jerosch, J. & Prymka, M., 1996).

Figure 21: The Sources of Somatosensory Sensations



Source: Adapted from Riemann & Lephart, 2002, p. 73.

We must keep in mind that proprioceptive work should focus on generating disturbances that stimulate the proprioceptors; this can be achieved in situations that are especially favorable to optimize the ability of reaction and equilibrium before that sudden stimuli, which can be done in static and dynamic ways. In the selection of tasks to complete, it is extremely important to stimulate the proprioceptors in the areas we are interested in, through the appropriate tasks (Romero, 2010).

Supporters of this kind of training argue that the unbalance generated by unstable platforms cause a larger stress to the neuromuscular system in comparison to the floor or fixed benches. According to this theory, strength gains would be due to mechanisms of muscle hypertrophy, and the optimization of neuromuscular coordination as a consequence of a better complementarity of the work among synergistic, stabilizing and antagonistic muscle groups.

When we talk about unstable methods, we refer to sitting, rolling, kneeling, lying down or standing on objects such as PhysioBalls (Swissball), dynamic discs (Dyna Discs), balance boards (WobbleBoard), high density foam rollers (FoamRoller), Bosu (stands for both sides to use), mattresses, mini trampolines, and other similar objects (Behm, D. G. & Anderson, K., 2006), although we could also create instability using objects that are half filled with liquid or sand.

While we could infer that this type of training only offers benefits to athletic performance,this method could be negative if we just focused on these kinds of exercises. Therefore, the goal of this analysis is that you incorporate the elements that allow you to introduce those sorts of tasks into an appropriate environment and within a varied and specific program.

Historically, rehabilitation and prevention of injuries (such as a sprained ankle or knee) have focused their work on muscle building and have ignored proprioceptive deficiencies. Proprioception is a matter of posture, of movement, of changes in equilibrium, as well as in knowledge of position, weight, and resistance to objects in relation to one's own body weight. Unstable bases are the answer to the problem of reeducation of the proprioceptive system to minimize the inconveniences caused by the lack of coordination (Hoffman, M. & Payne, V. G., 1995).

According to the specificity principle, the loads should replicate game situations, or, at least, be as close an approximation as possible. Since not all forces are generated under conditions of stability in matches (for example, a jump shot, or an opponent’s change of direction, a dribble to elude a defense, a pivot, etc.), training should attempt to replicate the demands of a game.

While in team sports nearly all situations occur in a dynamic equilibrium, traditional training occurs in situations of stationary equilibrium. With regards to this, Shimada et al. (2003) found no correlation between dynamic balance (a walk) and static balance, and other authors report secondary effects of balance and adjustment to disturbances. The problem is that in those studies one can only simulate relatively similar conditions; meaning, work on unstable platforms cannot exactly replicate game situations. Therefore, its effectiveness in improving performance is still up for debate (Wahl, M.J. & Behm, D.G., 2010). According to Willardson (2009):

> The optimal method to increase proprioception and stability in any sport consists in practicing the skills required in the sport on the same surface on which the competition takes place. Unfortunately, this is not always

possible, which is why alternative challenges may be necessary. (p. 108).

The utilization of unstable methods in training may stop the individual from generating maximum levels of strength and muscle power, and it is worth mentioning that as instability increases, there is a greater activation of the antagonist muscles to provide greater equilibrium, which may generate even bigger decreases in strength. With the purpose of analyzing the impact of training on unstable bases and different conditional variables, such as jumps, agility tests and 10 and 40 yard sprints, Cressey, West, Tiberio, Kraemery Maresh (2007) compared two training groups for ten weeks: one of them was performing exercises on inflatable bases, and the others performed the same exercises, but on the ground. The team that trained on a stable base had a superior performance in every aspect that was evaluated. The authors concluded that, while the utilization of unstable elements has shown to be effective in injury rehabilitation, their utilization to increase athletic performance should be carefully analyzed.

Let's summarize, then, the benefits of training on unstable surfaces:

- They reduce the risk of ankle and knee injury, which makes it an important method for prevention; here, Caraffa (1996) and Verhagen and Van Mechelen (2009) agree.
- They play an important part in the rehabilitation of ankle and knee ligament injuries (Lephart, S., Pincivero, D., & Giraido, J., 1997).
- It increases the activation of core musculature more than the same exercises on stable surfaces (Fowles, J., 2010).
- It improves muscle coordination and strategies of muscle activation in the ankle muscles (McKeon, P. & Hertel, J., 2008).
- It improves static equilibrium (Anderson, K. & Behm, D. G., 2005).

Finally, some things to take into consideration when training on unstable surfaces:

- Their effects on improvements to maximum strength and power are null or insignificant, at best, and should not be used as the main method for the development of these aspects (Cressey, E. et al. 2007).
- They have lower electric activation of leg and upper body musculature compared to the same exercises performed on stable surfaces (Behm, D. G. & Anderson, K. 2006).
- To avoid contradictions in the specificity of movement, it is important to control the execution of movements on unstable surfaces since, generally, they are performed at very low speeds, while action is generally very fast in sports (Willardson, J. Fontana, F. & Bressel, E. 2009).

References

Anderson, K., & Behm, D. G. (2005). *The impact of instability resistance training on balance and stability* (Author's translation). Sports medicine, 35(1), 43-53.

Bartonietz, K. E. (1996). *Biomechanics of the Snatch: Toward a Higher Training Efficiency* (Author's translation). Strength & Conditioning Journal, 18(3), 24-31.

Behm, D. G., & Anderson, K. G. (2006). *The role of instability with resistance training* (Author's translation). The Journal of Strength & Conditioning Research, 20(3), 716-722.

Behm, D. G., Anderson, K., & Curnew, R. S. (2002). *Muscle force and activation under stable and unstable conditions* (Author's translation). The Journal of Strength & Conditioning Research, 16(3), 416-422.

Behm, D. G., Drinkwater, E. J., Willardson, J. M., & Cowley, P. M. (2010). *Canadian Society for Exercise Physiology position stand: The use of instability to train the core in athletic and nonathletic conditioning* (Author's translation). Applied Physiology, Nutrition, and Metabolism, 35(1), 109-112.

Bértola, D. (2010). *Hans Selye y sus ratas estresadas.* Medicinauniversitaria,12(47), 142-143.

Bompa, T., & Buzzichelli, C. (2015). *Periodization Training for Sports* (Author's translation), *3E*. USA: Human Kinetics.

Canavan, P. K., Garrett, G. E., & Armstrong, L. E. (1996). *Kinematic and Kinetic Relationships Between an Olympic-Style Lift and the Vertical Jump* (Author's translation). The Journal of Strength & Conditioning Research, 10(2), 127-130.

Cappa, D. (2000). *Entrenamiento de la potencia muscular*. Mendoza: Dupligraf.

Caraffa, A., Cerulli, G., Projetti, M., Aisa, G., & Rizzo, A. (1996). *Prevention of anterior cruciate ligament injuries in soccer.* Knee surgery, sports traumatology, arthroscopy, 4(1), 19-21.

Cleak, M. J., & Eston, R. G. (1992). *Muscle soreness, swelling, stiffness and strength loss after intense eccentric exercise.* British Journal of Sports Medicine, 26(4), 267-272.

Comerford, M. J., & Mottram, S. L. (2001). *Functional stability re-training: principles and strategies for managing mechanical dysfunction* (Author's translation). Man Ther, 6(1), 3-14.

Cressey, E. M., West, C. A., Tiberio, D. P., Kraemer, W. J., & Maresh, C. M. (2007). *The effects of ten weeks of lower-body unstable surface training on markers of athletic performance* (Author's translation). The Journal of Strength & Conditioning Research, 21(2), 561-567.

Da Silva, M.E., Padullés, J.M., Núñez, V., Vaamonde, D., Viana, B., Gómez, J.R., & Lancho, J.L.(2005). *Análisis electromiográfico y de percepción de esfuerzo del Tirante Musculador con respecto al ejercicio medio squat*. Notes on Physical Education and Sports, 4th trimester, pp. 45-52.

Enoka, R. M. (1996). *Eccentric contractions require unique activation strategies by the nervous system* (Author's translation). Journal of Applied Physiology, 81(6), 2339-2346.

Fleck, S. (2011). *Non-linear periodization for general fitness & athletes* (Author's translation). Journal of human kinetics, 29 (Special Issue), 41-45.

Fowles, J. R. (2010). *What I always wanted to know about instability training* (Author's translation*).* Applied physiology, nutrition, and metabolism, 35(1), 89-90.

Frank Rothwell (Uploader). (2015, August 31). *NaimSuleymanoglu 150 kg Snatch* [Youtube video]. Retrieved from: https://www.youtube.com/watch?v=O5SqocMOiGs

Garhammer, J. (1979). *Power production by Olympic weightlifters* (Author's translation). Medicine and science in sports and exercise, 12(1), 54-60.

Garhammer, J. (1993). *A Review of Power Output Studies of Olympic and Powerlifting: Methodology, Performance Prediction, and Evaluation Tests* (Author's Translation). The Journal of Strength & Conditioning Research, 7(2), 76-89.

González de Suso, J. (Undated). Bases científicas del entrenamiento con el tirante musculador inventado y patentado por Hans Ruf Jiménez. Physiology department, Centre d'AltRendiment (CAR) SantCugat. Retrieved from: http://www.fiebrefutbol.es/wp-content/uploads/2012/08/Tirante-Muscular-2010.pdf

Haff, G. G., Whitley, A., & Potteiger, J. A. (2001). *A Brief Review: Explosive Exercises and Sports Performance* (Author's translation). Strength & Conditioning Journal, 23(3), 13.

Hoffman, M., & Payne, V. G. (1995). *The effects of proprioceptive ankle disk training on healthy subjects* (Author's translation). Journal of Orthopaedic& Sports Physical Therapy, 21(2), 90-93.

Hoffman, J. R., Ratamess, N. A., Klatt, M., Faigenbaum, A. D., Ross, R. E., Tranchina, N. M., & Kraemer, W. J. (2009). *Comparison between different off-season resistance training programs in Division III American college football players* (Author's translation). The Journal of Strength & Conditioning Research, 23(1), 11-19.

Hori, N., Newton, R. U., Andrews, W. A., Kawamori, N., McGuigan, M. R., & Nosaka, K. (2008). Does *performance* of hang power clean differentiate *performance* of jumping, sprinting, and changing of direction? (Author's translation). *The Journal of Strength & Conditioning Research*, *22*(2), 412-418.

Hortobágyi, T., Houmard, J., Fraser, D., Dudek, R., Lambert, J., &Tracy, J. (1998). *Normal forces and myofibrillar disruption after repeated eccentric exercise* (Author's translation). Journal of Applied Physiology, 84(2), 492-498.

[Untitled image of the Yo-Yo machine]. (Undated). Retrieved from: http://www.efisioterapia.net/cursos/22844-fundamentos-y-metodologia-trabajo-excentrico-aplicado-recuperacion-y-prevencion?qt-lo_ltimo_=0

[Untitled image about conical pulley]. (Undated). Retrieved from: http://byomedicsystem.es/1631-thickbox_default/eccotek-training-force-polea-conica.jpg

Inerxial (Uploader). (2013, November, 13) *Polea Cónica Inercial - Características Técnicas* [Youtube video]. Retrieved from:https://www.youtube.com/watch? v=9ok1gw8dg5U

Issurin, V. B. (2010). *New horizons for the methodology and physiology of training periodization* (Author's translation). Sports medicine, 40(3), 189-206.

Jerosch, J., & Prymka, M. (1996). *Proprioception and joint stability. Kneesurgery, sportstraumatology, arthroscopy*, 4(3), 171-179.

Jordi Cañadas (Uploader). (2014, August 16). *Preparacion Fisica Aplicada A Los Deportes Colectivos Balonmano Seirul lo* [Youtube video]. Retrieved from: https://www.youtube.com/watch?v=uSJ-r3p5ldQ

Kettlebellsport (Uploader). (2013, February, 22). *VasilyAlekseyev - Clean and Jerk 534.5 lb / ВасилийАлексеевтолчок 242,5 кг*[Youtube video].Retrieved from https://www.youtube.com/watch?v=34SVc9BMi18

Kok, L. Y., Hamer, P. W., &Bishop, D. J. (2009). *Enhancing muscular qualities in untrained women: linear versus undulating periodization* (Author's translation). Medicine & Science in Sports& Exercise, 41(9), 1797-807.

Kraemer, W. J., & Fleck, S. J. (2007). *Optimizing strength training: designing nonlinear periodization workouts* (Author's translation). USA: Human Kinetics.

Langberg, H., Ellingsgaard, H., Madsen, T., Jansson, J., Magnusson, S. P., Aagaard, P., & Kjær, M. (2007). *Eccentric rehabilitation exercise increases peritendinous type I collagen synthesis in humans with Achilles tendinosis*(Author's translation). Scandinavian journal of medicine & science in sports, 17(1), 61-66.

Lephart, S. M., Pincivero, D. M., Giraido, J. L., & Fu, F. H. (1997). *The role of proprioception in the management and rehabilitation of athletic injuries* (Author's translation). The American journal of sports medicine, 25(1), 130-137.

Linnamo, V. (2002). *Motor unit activation and force production during eccentric, concentric and isometric actions* (Academic dissertation) (Author's translation). Neuromuscular Research Center, Department of Biology of Physical Activity, University of Jyväskylä. Retrieved from: https://jyx.jyu.fi/dspace/bitstream/handle/123456789/13497/9513912205.pdf?sequence=1

Marqueste, T., Decherchi, P., Messan, F., Kipson, N., Grélot, L., & Jammes, Y. (2004). *Eccentric exercise alters muscle sensory motor control through the release of inflammatory mediators* (Author's translation). Brain research, 1023(2), 222-230.

McHugh, M. P., Connolly, D. A., Eston, R. G., Gartman, E. J., & Gleim, G. W. (2001). Electromyographic analysis of repeated bouts of eccentric exercise (Author's translation). *Journal of sports sciences*, *19*(3), 163-170.

McHugh, M. P. (2003). *Recent advances in the understanding of the repeated bout effect: the protective effect against muscle damage from a single bout of eccentric exercise* (Author's translation). Scandinavian journal of medicine & science in sports,13 (2), 88-97.

McHugh, M. P., Connolly, D. A., Eston, R. G., & Gleim, G. W. (1999). *Exercise-induced muscle damage and potential mechanisms for the repeated bout effect* (Author's translation). Sports Medicine, 27(3), 157-170.

McKeon, P. O., & Hertel, J. (2008*). Systematic review of postural control and lateral ankle instability, part II: is balance training clinically effective?* (Author's translation). Journal of athletic training, 43(3), 305-315.

Mckeon, P., Ingersoll, C., Kerrigan, D. C., Saliba, E., Bennett, B., & Hertel, J. (2008). *Balance training improves function and postural control in those with chronic ankle instability* (Author's translation). Medicine& Science in Sports & Exercise, 40(10), 1810.

MacKenzie, S. J., Lavers, R. J., & Wallace, B. B. (2014). *A biomechanical comparison of the vertical jump, power clean, and jump squat* (Author's translation). Journal of sports sciences, 32(16), 1576-1585.

Monteiro, A. G., Aoki, M. S., Evangelista, A. L., Alveno, D. A., Monteiro, G. A., da Cruz Piçarro, I., & Ugrinowitsch, C. (2009). *Nonlinear periodization maximizes strength gains in split resistance training routines* (Author's translation). The Journal of Strength & Conditioning Research, 23(4), 1321-1326.

Noonan, T. J., & Garrett Jr, W. E. (1999). *Muscle strain injury: diagnosis and treatment* (Author's translation). Journal of the American Academy of Orthopaedic Surgeons, 7(4), 262-269.

Norrbrand, L. (2008). *Acute and early chronic responses to resistance exercise using flywheel or weights* (Doctoral thesis) (Author's translation). Retrieved from http://miun.diva-portal.org/smash/get/diva2:332124/FULLTEXT01.pdf

Norrbrand, L., Fluckey, J. D., Pozzo, M., & Tesch, P. A. (2008). *Resistance training using eccentric overload induces early adaptations in skeletal muscle size* (Author's translation). European Journal of Applied Physiology, 102(3), 271-281.

Norrbrand, L., Pozzo, M., &Tesch, P. A. (2010). *Flywheel resistance training calls for greater eccentric muscle activation than weight training* (Author's translation). European Journal of Applied Physiology, 110(5), 997-1005.

Nørregaard, J., Larsen, C. C., Bieler, T., & Langberg, H. (2007). *Eccentric exercise in treatment of Achilles tendinopathy* (Author's translation). Scandinavian journal of medicine & science in sports, 17(2), 133-138.

Nosaka, K., Newton, M., & Sacco, P., (2002). Delayed-onset muscle soreness does not reflect the magnitude of eccentric exercise-induced

muscle damage (Author's translation). *Scandinavian journal of medicine & science in sports, 12(6), 337-346.*

Nosaka, K., & Newton, M., (2002). Repeated eccentric exercise bouts do not exacerbate muscle damage and repair(Author's translation). *The Journal of Strength & Conditioning Research*, *16*(1), 117-122.

Prestes, J., De Lima, C., Frollini, A. B., Donatto, F. F., & Conte, M. (2009). *Comparison of linear and reverse linear periodization effects on maximal strength and body composition* (Author's translation). The Journal of Strength and Conditioning Research, 23(1), 266-274.

Rules and technical regulations of the IWF competition. (2013).Approved in the IWF congress (International Weightlifting Federation), in Bakú, Azerbaiyan.

Rhea, M. R., Ball, S. D., Phillips, W. T., & Burkett, L. N. (2002). *A comparison of linear and daily undulating periodized programs with equated volume and intensity for strength* (Author's translation). The Journal of Strength & Conditioning Research, 16(2), 250-255.

Rhea, M. R., & Alderman, B. L. (2004). *A meta-analysis of periodized versus nonperiodized strength and power training programs* (Author's translation). Research quarterly for exercise and sport, 75(4), 413-422.

Riemann, B. L., &Lephart, S. M. (2002). *The sensorimotor system, part I: the physiologic basis of functional joint stability. Journal of athletic training*, 37(1), 71.

Schelling, X. (2009). *Entrenamiento de la Fuerza. Niveles de aproximación* (Catalán). Revista de la Associació Catalana d' Entrenadors de Basquetbol. "Minut ACEB", 1(4), 18-21.

Seirul-lo, F. (1990). *Entrenamiento de la fuerza en balonmano.* Red: revista de entrenamiento deportivo, 4(6), 30-34.

Seirul-lo, F. (1994). *Preparación física aplicada a los deportes colectivos. Balonmano*. Santiago de Compostela: Lea.

Servicio Médico Barcelona, F. C. (2012). *Guía de práctica clínica de las tendinopatías: diagnóstico, tratamiento y prevención. Apunts. Medicina de l'Esport, 47(176), 143-168.*

Shimada, H., Obuchi, S., Kamide, N., Shiba, Y., Okamoto, M., & Kakurai, S. (2003). *Relationship with dynamic balance function during standing and walking*. American journal of physical medicine & rehabilitation, 82(7), 511-516.

Shimano, T., Kraemer, W. J., Spiering, B. A., Volek, J. S., Hatfield, D. L., Silvestre, R., & Newton, R. U. (2006). *Relationship between the number of repetitions and selected percentages of one repetition maximum in free weight exercises in trained and untrained men* (Author's translation). The Journal of Strength & Conditioning Research, 20(4), 819-823.

Siff, M. C., & Verkhoshansky, Y. (2004). *Superentrenamiento (Vol. 24)*. Barcelona: Paidotribo.

Solé Fortó, J. (2008) *Planificación del entrenamiento deportivo*. Barcelona: Sicropat Sport.

Solomonow, M., & Krogsgaard, M. (2001). *Sensorimotor control of knee stability. A review* (Author's translation). Scandinavian journal of medicine & science in sports, 11(2), 64-80.

Stone, M. H. (1993). *Position statement: Explosive Exercise and Training* (Author's translation). Strength & Conditioning Journal, 15(3), 7-15.

Tous Fajardo, J. (2010). Chap. 7: *Entrenamiento de la fuerza mediante sobrecargas excéntricas. En Prevención de lesiones en el deporte: Claves para un rendimiento deportivo óptimo,* pp. 217-232. Buenos Aires: Editorial Médica Panamericana.

Tous-Fajardo, J., Norrbrand, L., Pozzo, M., &Tesch, P. (May, 2006). Quadriceps electromyographic activity during two different squat activities: flywheel multigym vs barbell half-squat (Author's translation). At *I Congreso Internacional de Avances en Ciencias de la Actividad Física y el Deporte*. Congress taking place in Seville, Spain.

Verhagen, E. A., & Van Mechelen, W. (2009*). Effect of unsupervised home based proprioceptive training on recurrences of ankle sprain: randomised controlled trial* (Author's translation). British Medical Journal, 339, b2684.

Wahl, M. J., & Behm, D. G. (2008). *Not all instability training devices enhance muscle activation in highly resistance-trained individuals* (Author's translation). The Journal of Strength & Conditioning Research, 22(4), 1360-1370.

Willardson, J., Fontana, F. E., & Bressel, E. (2009). *Effect of surface stability on core muscle activity for dynamic resistance exercises* (Author's translation). International Journal of Sports Physiology and Performance 4(1), 97-109.

Zawieja-Koch, M. (2005a). *Weightlifting in training for athletics – Part I* (Author's translation). *NSA*, *20*(1), 7-23. IAAF. Retrieved from http://richwoodstrack.com/rhs_team_area/meet_mastery/tech_Weight%20training%20Pt%201.pdf

Zawieja-Koch, M. (2005b). *Weightlifting in training for athletics* - Part II (Author's translation). NSA, 20(2),38,-43,IAAF. Retrieved from: http://richwoodstrack.com/rhs_team_area/meet_mastery/tech_Weight%20training%20Pt%202.pdf