3.2 Training Management

3.2.1 Technology Applied to Training Management

In recent years, thanks to the phenomenon of globalization and incredible technological evolution, ideas, concepts, objectives, and teaching and learning strategies have expanded, which not only affect society and daily life, but also impact on sports and physical exercise (Bagnara, I., 2011). The latter are strongly influenced by technology, which has played a major role in the evolution of training in recent years.

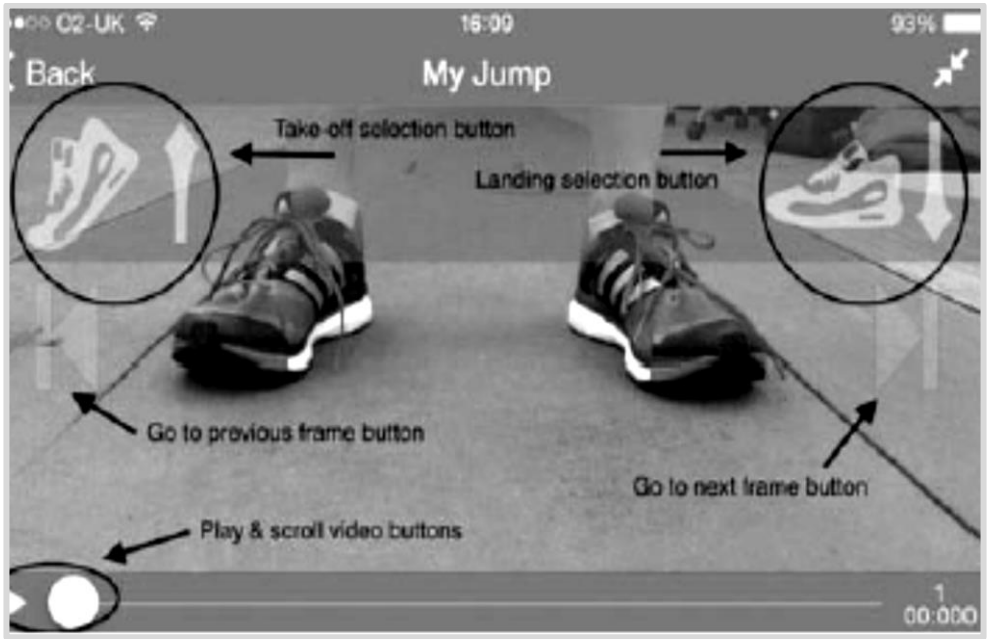
The rise of science applied to sports training has generated the possibility of designing technological devices applied to sports. Nowadays, there are numerous devices that have been designed to measure, plan and evaluate sports performance. These are devices that collect information on the intensity of training, the functional state of the athlete, and the body's ability to adapt to training loads. The purpose of applying technology in sports is to reduce training programming errors and therefore reduce the number of injuries caused by the erroneous design of tasks and their respective intensities.

Currently, cell phones are a powerful tool to increase the quality of the training process. With no commercial interest, we will now analyze some of the applications and tools available to the trainer that make it possible to increase the quality of their work. Since the use of state-of-the-art devices allows us to measure variables reliably, this can be very important both for designing new methods and training activities, as well as for disseminating high-quality, scientifically-based information to the various stakeholders involved in sport.

My Jump

Vertical jump tests are among the most common means to assess physical fitness regardless of the sport or the population analyzed. The first jump tests were primarily designed to assess the strength of legs in sports such as basketball, volleyball, or soccer.

Figure 3: My Jump



Source: Balsalobre-Fernández, Glaister & Lockey (2015), p. 3.

Research by Balsalobre-Fernández, Glaister & Lockey (2015) analyzed the validity and reliability of a phone application to measure performance in a counter movement jump (CMJ). Compared to a strength platform, the My Jump application was found to be valid and extremely reliable, especially considering that the device mentioned above is the one that is used as *par excellence* in scientific research. However, the equation used by the application analyzes flight time squared, so higher flight times have a slightly higher measurement error (1.6 cm) relative to a strength platform. Either way, carrying cellphone in one's pocket can be a scientifically validated way of monitoring and assessing explosive leg strength without the need to carry expensive equipment to training.

GPS Systems

Many people who watch first level team training ask themselves: What are those vests used by players? What are they for? These vests contain a **GPS (Global Positioning System)** which makes it possible for the player's location to be monitored via satellites. This device was initially designed for military purposes (Cummins, C. O'Connor, H. & West, C., 2013). In addition to GPS, these vests feature built-in accelerometers. Thus, through these instruments, primary variables such as speed, distance, acceleration and deceleration, impact, muscle fatigue index and runs exceeding 21 km/h (considered a sprint) are monitored (Coutts, A. & Duffield, R., 2010). These accelerations and sprints are the most important data in terms of assessing the risks of injury. Another feature

offered by these vests is the representation of a thermal image to express where and how much the athlete runs.

Coaches seem to understand that, for the first time, they have all the technological tools available to warn them of future injuries and also to quantify fatigue values or muscle wear and tear. Among other things, this helps coaches to align the team for the next match and put their rotations into practice with the idea of reaching the end of competition with more athletes and in better shape. Although vests have the disadvantage that they cost a lot of money which makes them difficult to implement in all institution, the use of these vests has become almost essential in world-class teams, not only in soccer but also basketball, rugby, hockey, handball, etc.

Figure 4: GPS Systems

Source: [Untitled image of GPS 1 systems]. (Undated). Retrieved from: http://goo.gl/4GvTCI
[Untitled image of GPS 2 systems]. (Undated). Retrieved from: http://goo.gl/EIRTMD

Velocity Based Training (VBT) measured through linear encoders or accelerometers.

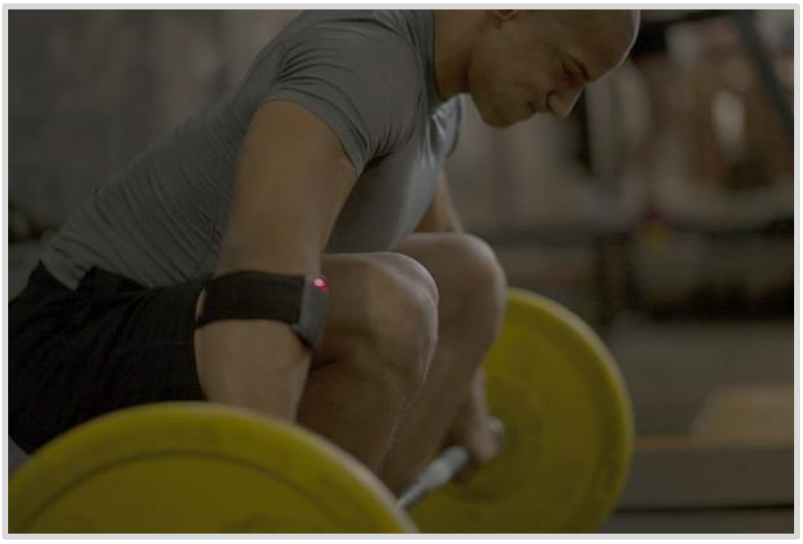
For decades, traditional training to increase neuromuscular performance measures (strength and power) consisted in working at different percentages of one rep maximum (1RM) and modifying variables such as the frequency and volume of training. However, nowadays, using velocity to achieve specific training goals has become more popular in scientific literature and in fitness centers (Mann, J. B., Ivey, P. A. & Sayers, S. P., 2015).

Figure 5: VBT

Source: [Untitled image of VBT]. (Undated). Retrieved from: http://goo.gl/kuE4s2

VBT is a method using accelerometers or linear encoders (see Figure 5) to measure the speed of the bar, dumbbell or other equipment. Generally, encoders work by converting a physical attribute (the position change of the cable attached to the bar, for example) into a set of digital pulses; usually, this device is connected to a personal computer with a software that interprets the data (Harris, N., Cronin, J. Taylor, K., Boris, & Sheppard, J., 2010). On the other hand, accelerometers are sensors that measure the inertial force generated in the three planes when a mass (the athlete's body or equipment) is affected by a velocity change (Boyd, L., Ball, K., & Aughey, R., 2011).

Figure 6: Accelerometer



Source: [Untitled image of an accelerometer]. (Undated). Retrieved from: http://goo.gl/OjjZ7l

There are different brand names for these accelerometers, some of which are: Tendo Units, Gym Aware and Push Strength. Encoders use specific software, the brand names of which depend on their geographical location; some of the best known are: Musclelab, Win laborat and Techfit. Thanks to these devices, trainers now have the ability to monitor, assess, and train athletes giving the coach instant and objective feedback of how training affects some variables of an athlete's performance.

There are several reasons why trainers should consider implementing VBT:

1) **It makes it possible to identify the daily fluctuations as a result of stress, for example, and thus adjust loads:** since it is an average speed and not a percentage of 1RM, the athlete can use the appropriate load for a given day; this makes trainers and athletes rethink the notion of a rep maximum value as constant and invariable.
2) **It makes it possible to recognize optimal speeds and loads in training to increase its specificity:** if a counter movement jump has a speed of 3.4 to 3.04 m/s (Cormie, P., & McBride, J.M., 2009) and in the weight room we do squats at a rate of 0.3 to 0.8 m/s throughout the year (Mann, J.B., et al., 2015), we are not adjusting exercises to the speed that the motor pattern of the sport requires.
3) **It gives the athlete and trainer immediate feedback**, which motivates the athlete and increases the quality of training.

On the other hand, the limitations this type of training has are:

- Accelerometers or encoders to measure speed can be costly for the trainer.
- They require the trainer to give up some control and hand over a certain level of autonomy, as the athlete has the ability to correctly select the loads and perform each rep at the maximum possible speed.
- Reviewing the data of some software packages can be complex and slow, which wastes training time.

3.2.2 What is the Core? A Proposal for Training

Core musculature is composed of 29 pairs of muscles that support the complex of the **hip-lumbar spine-pelvis region**. These muscles help stabilize the spine, pelvis, and the kinetic chains during functional motions. When this system works efficiently, the result is an optimal distribution of strength, adequate absorption of impact on the ground, an absence of excessive compression and transference, or shear force on

the joints involved in a particular chain of movement (Fredericson, M., & Moore, T., 2005). To summarize, core musculature plays an important role in:

- Trunk rotation.
- Transfer of force to limbs.
- Stability of the lumbar-pelvic region (Bliss L. S. y Teeple, P., 2005).

Considering the wide variety of existing motions in sports, players need to have sufficient strength in the hips and trunk to provide stability in all three planes of motion. This is sufficient reason to consider that core stability plays a key role in preventing injuries (Leetun, Ireland, Willson, Ballantyne, & Davis, 2004).

Stability of the lumbar-pelvic region helps to prevent significant displacement of the spine and return to equilibrium after suffering a disturbance. Although the passive elements (bone and ligaments) contribute to a lesser extent, this stability is maintained dynamically by the muscles in the region (Wilson, J. D., Dougherty, C. P., Ireland, M. L., & Davis, I. M., 2005).

These muscles can be divided into two systems depending on whether they act as a stabilizer or as the primary action of the movement (see Table 3). Local muscles are characterized by being shorter, they are inserted directly into the vertebrae and generate enough force to stabilize the spine (Faries, M. D., & Greenwood, M., 2007). Within this group, it was confirmed that the transversus abdominis (TrA) is of great importance when verifying its activation 100 milliseconds before the start of the movement of the legs in a reaction test (Hagins, M., Adler, K., Cash, M., Daugherty, J., & Mitrani, G., 1999).

Table 3: Core Musculature

Core Musculature		
Local Muscles (Stabilization System)		Global Muscles (Movement System)
Primary Stability	Secondary Stability	
• Transversus abdominis • Multifidus	• Internal oblique • Medial fibers of the external oblique • Quadratus lumborum • Diaphragm • Pelvic floor • Iliocostalis and longissimus lumbar region	• Rectus abdominis • Lateral fibers of the external oblique • Psoas major • Erector spinae • Iliocostalis (thoracic portion)

Source: Adapted from Faries & Greenwood, 2007, p. 12.

Multifidus and TrA are considered primary muscles as they do not generate movement of the spine, while the internal oblique, medial fibers of the external oblique, and quadratus lumborum, although their main task is to provide stability to the spine, play a secondary role in the movement of same.

Muscles responsible for producing movement and torque in this region are called global muscles. These have large levers which help them generate great speed, power, and force or torque motions that cover multiple planes while dealing with external loads that are transferred to the local musculature (Faries, M. D., & Greenwood, M., 2007).

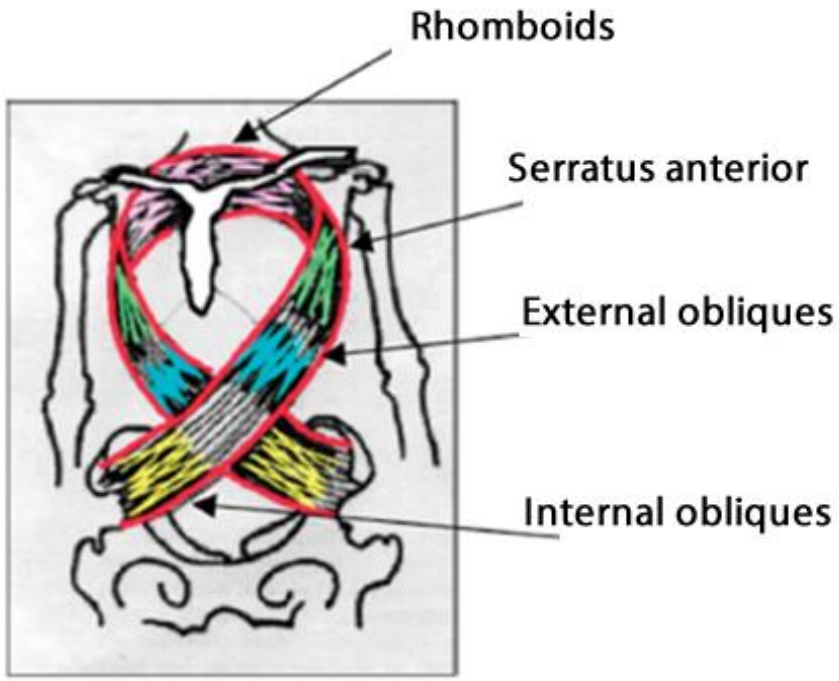
As we emphasized earlier, it is very important to maintain stability in this area of the body. This is even clearer if we consider the large compression forces acting on the lumbar discs in sports training and practice, where doing a half squat can represent a force of between six and ten times the body weight on the L4 and L5 vertebrae
(Cappozzo, A., Felici, F., Figura, F., & Gazzani, F., 1985). This means that an athlete who weighs 90 kg (198 lb.) lifts a weight of 145 kg while doing squats, applying a compression force of approximately 900 kg to the lumbar spine.

Transfer of Force from the Core to the Limbs - the Serape Effect

The **serape effect** was named after a traditional Mexican garment consisting of a band of fabric that goes behind the neck and crosses the front of the chest (see Figure 7).

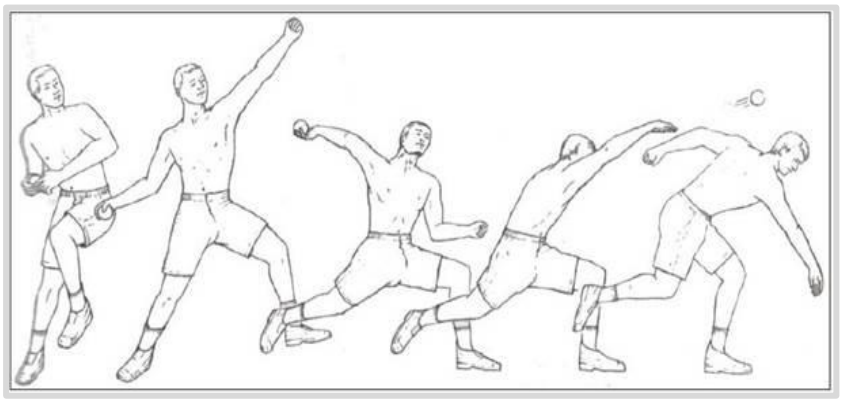
This effect is a process by which the force generated in the trunk is transferred to the limbs. A great example of this is a jump shot in handball. What is not visible is that the abdominal muscles, particularly the transverse muscles, are activated before the arm and leg movements start. Consequently, while the athlete carries the ball behind his head, the transverse becomes the first fixation of the body and the core generates the power that will be subsequently transferred to the shoulder, elbow, wrist, and finally the throwing of the ball.

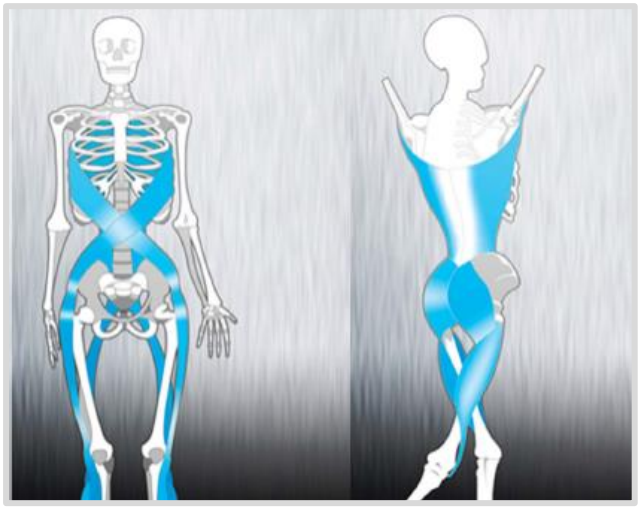
Figure 7: Serape



Source: Santana, McGill, & Brown, 2015, p. 10; Santana, McGill, & Brown, 2015, p. 9.

Figure 8: Serape during Shot





Source: Santana, McGill, & Brown, 2015, p. 9; Santana, McGill, & Brown, 2015, p. 11.

How to Train the Core – Establishing a Progression

First of all, the **correct technique** is essential in this type of exercise because wrong execution puts the athlete at risk of injury. It is therefore necessary for the athlete to learn to activate local stabilizing muscles before producing more complex motions. Another important aspect to address is **diaphragmatic breathing**, as this muscle is the "ceiling" of the core and, when contracted, it increases intra-abdominal pressure and thus increases the stability of the lumbar-pelvic region (Cappozzo, A., Felici, F., Figura, F., & Gazzani, F., 1985).

Once the athlete is able to stabilize the lumbar-pelvic region from isometric exercises, McGill (2010) recommends incorporating the following exercises known to be the three most important exercises for core muscles:

1) ***Curl-ups*** for the rectus abdominis. The rectus is very active during the initial phase of lifting of the head, neck and shoulder, and the lumbar spine should be neutral.

2) ***Side bridges*** for oblique, transverse abdominis, latissimus dorsi, and lumbar quadrate. This exercise is very challenging for lateral oblique and rectus without generating high compression loads on the spine.
3) The ***bird-dog*** in quadruped position performing a knee extension and opposite elbow to stimulate the lower back extensors.

As these exercises progress, one can switch from a stable to an unstable surface using tools and adding complexity to these tasks.

To conclude this section, we summarize the proposal of Bliss and Teeple (2005) who established the following principles to be followed in relation to the progression:

1) Moving from stable to unstable surfaces and from static to dynamic.
2) Perform exercises in all three planes: sagittal, horizontal and transverse.
3) Incorporating proprioceptive and increasing difficulty elements (suspension training, physio balls, etc.).
4) Carry out explosive strength exercises, multijump, and sports specific motions tailored to the player's needs.

3.2.3 Warm-Up and Post-Activation Potentiation

Warm-up prior to competition or training is an activity included in sports. Trainers and athletes consider it essential in their quest to achieve optimal performance. However, these considerations have not always been well supported by substantial empirical evidence, so trainers reached conclusions about their warm-up practices and strategies based on trial and error (McGowan, C. J., Pyne, D. B., Thompson, K. G., & Rattray, B., 2015). Due to this, extensive research has been conducted to determine the key elements in these tasks.

The objectives of proper and effective warm-up are:

- Socio-affective arousal (psychological aspects).
- Prevent muscle and joint injuries.
- Optimize performance through increased body temperature and increased metabolic and physiological reactions of the athlete's body.

According to Kirkendall (2014), the following components should not be missing from a warm-up prior to a sporting event:

- Aerobic activation of progressive intensity.
- Strength exercises for issue areas.
- Static and dynamic stability activities.

- Dynamic stretches.
- Agility and plyometrics tasks.
- Motor control activities related to the sport.

Among the physiological and neural mechanisms that have been discussed in the scientific literature regarding warm-up, are: increased muscle metabolism, increased oxygen consumption, and post activation potentiation (PAP). Among these, one of the physiological objectives pursued is increased body temperature, based on the increase of muscle metabolism and nerve conduction (see Table 4).

Table 4: Possible Effects of Warm-Up

Effects Related to Increased Temperature	Effects Not Related to Increased Temperature
Decreased muscle and joint viscoelastic resistance	Increased blood flow to muscles
Increased release of oxygen from hemoglobin and myoglobin	Elevated base oxygen consumption
Acceleration of metabolic reactions	Post-activation potentiation (PAP)
Increased nerve conduction speed	Psychological effects - social-affective aspects.
Improvement in the body's thermoregulatory ability	

Source: Adapted from Bishop, 2003.

Traditionally, before matches, teams have always performed a sequence involving aerobic activation: running at low intensity, joint mobility exercises, and sport specific tasks with or without the ball. These warm-ups lasted on average 30 minutes with a transition of 12 minutes between the end of the warm-up and the beginning of the match. Likewise, in all sports it is common to have a half-time break of about 10 to 15 minutes between the first and second halves (Mc Gowan et al., 2015).

Warm-ups that include **small-sided games** (2 vs. 2, 3 vs. 3, 4 vs. 4, etc.) provide additional benefits over generic activation, since they promote neuromuscular activation and coordinative work (Gabbett, T. J., 2008). These games are designed to stimulate the specific needs of the sport, both technical and tactical components and physiological aspects since sport-specific tasks such as passing, shooting, and ball control are repeated in the game. Zois, Bishop, Ball and Aughey (2011) found improvements in vertical jump, repeated sprints and agility in soccer

players after implementing small-sided games (SSG) compared to traditional warm-ups.

When using SSG, it is recommended that they last less than 16 minutes and be implemented as close as possible to the match, preferably within less than ten minutes (McGowan et al., 2015). SSGs can also be implemented during half-time, in which case they should last 3 to 7 minutes to maintain elevated body temperature and the athlete's predisposition to continue performing during the second part of the game.

Post-activation potentiation (PAP)

Doing rep maximums or sets of an exercise or close to the maximum in order to increase strength/power in subsequent exercises is what is known as ***post-activation potentiation (PAP)*** (Seitz, L. B., & Haff, G. G., 2016). It has been proven that under these criteria, performing squats or power snatches can significantly increase subsequent performance in vertical and horizontal jumps or sprints of 10 and 40 m.

The effects of PAP are divided into muscle and nerves. At the muscle level, it has been found that the rep maximums provoke a phosphorylation of myosin light chains, thereby increasing the sensitivity of the actin-myosin complex of the calcium that is released from the endoplasmic reticulum causing increased activity of cross-bridges (Tillin, M. N. A., & Bishop, D., 2009). On the other hand, in the central nervous system, effects would be related to the increased recruitment of high threshold motor units (MU), increased MU synchronization and lower activity of reciprocal inhibition reflex by antagonists Tillin, M. N. A., & Bishop, D., 2009).

The factors affecting the magnitude of PAP are:

- **The athlete's level of experience and strength:** stronger players have greater power than weaker players and are able to express this increase in less time (Seitz, L. B., de Villarreal, E. S., & Haff, G. G, 2014).
- **The type of potentiating exercise and its technique: three power snatches** at 90% of 1 RM can produce a more pronounced positive effect in 20 m sprints than three reps at 90% in squats; in addition, the depth of the squat can affect the level of PAP time (Seitz, L. B., de Villarreal, E. S., & Haff, G. G, 2014).
- **The rest between the execution of the potentiating exercise and powered activity:** it would seem that the benefits range from 5 to 18.5 minutes, although the best results are between 7 to 10 minutes (Wilson et al, 2013).

- **The number of potentiating exercise sets:** there are greater effects when doing multiple sets rather than just one set (Wilson et al, 2013.).
- **The intensity to be used**: moderate loads of between 60% and 84% provide better results than very heavy loads (over 85%) or light loads (under 60%).
- **There seem to be no differences in gender.**

The exercises to be used, in addition to traditional exercises (squats, flat press) or weight lifting derivatives, progressive intensity multijump and medicine ball multi-throw, among others; all these exercises can be effective means to produce PAP and should be included in any competition preparation activity.

3.2.4 Fatigue and Recovery After a Session or Match

An extremely important factor in the performance of a sports team is the proper recovery of the state of fatigue after a game or training, especially in conditions under which athletes train and play sometimes on the same day, on successive days, or every other day, with little time to rest. It is worth noting that, if we can get athletes to recover faster from a state of fatigue, they will have a clear performance advantage compared to opponents who have not applied any recovery method (Terrados, N., Calleja-González, J., & Schelling, X., 2011).

According to Terrados (2011): "Sports fatigue is a state in which the athlete is unable to maintain the expected level of performance or training." Two types can be distinguished:

- ***Central Fatigue:*** according to which the muscles are able to generate high power, but the nervous system blocks them, perhaps as a means of protecting them from injury (Bishop, D., 2003).
- ***Peripheral Fatigue:*** where muscle homeostasis has been disturbed, either metabolically or through tissue damage, to the point that the muscle is biochemically or biomechanically unable to respond effectively to the effort as when it is rested (Bishop, D., 2003).

Currently, and from a sports point of view, the main mechanisms of fatigue are the following (Terrados, 2009):

1) Substrate depletion.
2) Excess in accumulation of metabolites derived from exercise.
3) Very high temperatures.
4) Muscle damage after a workout.
5) Changes in the immune system.

6) Hormonal variations.

In international soccer, the number of matches per season, counting home and away matches and national representative events, is very high. During the 2009-2010 season, counting the FIFA World Cup, many Spanish players played up to 70 competitive matches. It is known that participation in a soccer match leads to a decrease in performance during the following hours and days caused by a state of acute fatigue. Andersson et al. (2008) found that elite soccer players need at least 72 hours to get their physical performance, inflammation and muscle damage back to levels in the hours before the last game. At certain times of the season in which the competition calender does not allow a rest, the team must play two matches in the same week and the time to recover after playing successive matches may be 3 to 4 days, a period that may be insufficient for certain players in relation to the body's ability to restore homeostasis. As a result of the repetition of these events, the player can experience acute and chronic states of fatigue, which ultimately leads to a potential state of low performance and/or injuries. Ekstrand, Waldén, & Hägglund (2004) found that those players with low performance in the soccer World Cup in 2002 had played an average of 12.5 matches in the ten weeks prior to the event. In contrast, those who showed a high level of play had played only 9 mathces in that same time. In addition to this, Dupont et al. (2010) found that players who play two matches a week and get between 72 and 96 hours rest are 6.2 times more likely to be injured than soccer players who only play one match every seven days.

Competitive and training demands impose a substantial burden on the athlete. The musculoskeletal, nervous, immune and metabolic systems are highly affected to the point that recovery strategies after the match become necessary and are crucial in preparing for the next match (Ascensão et al., 2008). Other factors need to be taken into account, such as mental preparation and pre-match travel as precursors to a state of fatigue. Playing away, especially coupled with long trips and nights of rest in unfamiliar environments, has a negative impact on sleep quality and this can affect player performance (Bengtsson, H., Ekstrand, J., & Hägglund, M., 2013).

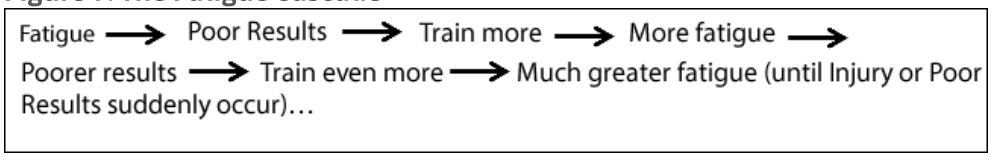
On the other hand, it is important to acknowledge that in team sports we should not only focus on the physiological etiology of fatigue. The detailed assessment of the influence of the location of the match, the level of the opponent, the score and the emergence of critical moments in the match on physical performance present, in team sports, a number of practical implications of great importance for trainers and physical trainers in the analysis of team fatigue (Lago Peñas, C. Martín Acero, R., Seirul-lo Vargas, F., Alcalde, J., y Hernández Moreno, J., 2011). First, it would be useful to incorporate in the post-match analysis of the team's physical performance, the specific characteristics of the situational

variables that came up in the match, such as the influence of tactical and strategic factors, since a decrease in performance during a match may not just be the result of the players' physiological fatigue. Second, if the coach or physical trainer is able to identify aspects of team performance that are negatively influenced by some situational variable or critical moment, the causes of this deterioration can then be isolated and taken into account specifically in preparing for the following matches during training (Lago Peñas et al., 2011).

We must consider a very important aspect related to fatigue that has to do with several pathologies (some quite serious) that are concurrent to fatigue, but which must be distinguished from it. It is important to have a proper medical diagnosis so that low performance due to the onset of some kind of pathology is not confused with sports fatigue, as this could pose a serious misdiagnosis.

As we have seen, it is essential to know what type of fatigue the athlete is suffering from in order to support recovery. Thus, for example, it would not be effective to use strategies for rapid recovery of muscle glycogen if the athlete's fatigue is actually psychological. Without the correct analysis of the etiology of the loss of condition, we often fall into the following sequence of errors:

Figure 9: The Fatigue Cascade



Source: Adapted from Terrados (2012), unpublished notes.

This is why the correct quantification of training loads is essential. As we saw earlier, knowledge of a sport's fatigue mechanisms greatly helps in the planning of training and recovery strategies for the athlete, which is important to maintaining their health and good physical fitness. Both with regards to soccer and other team sports, Nédélec (2013) refers to fatigue as a multifactorial phenomenon related to:

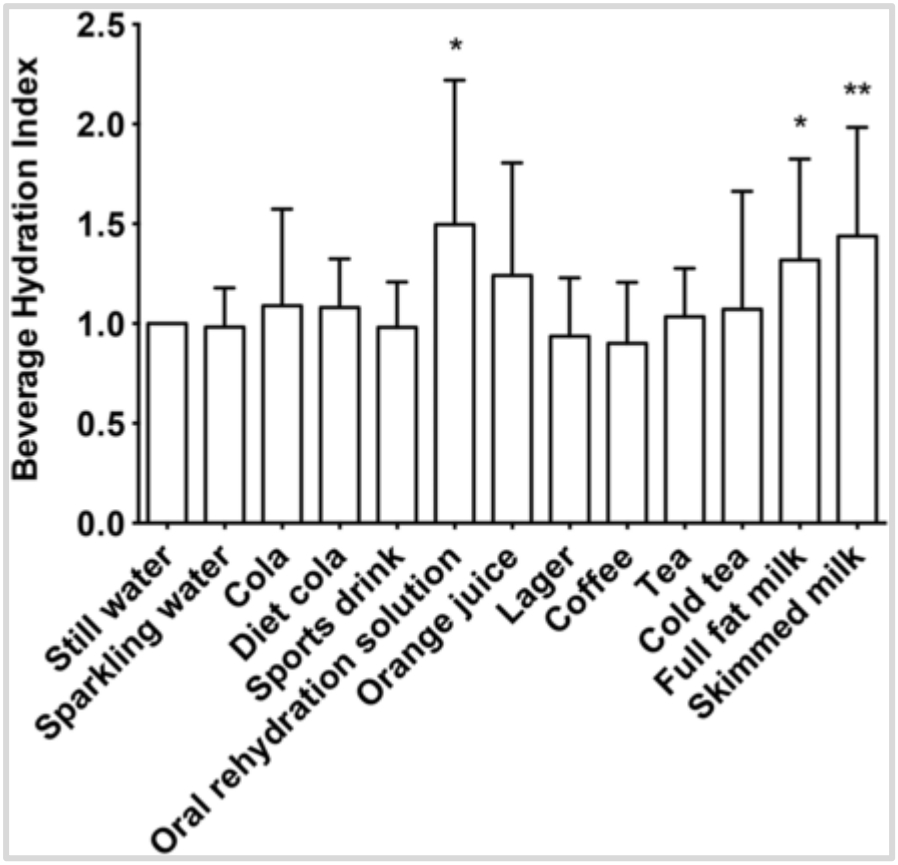
- Dehydration.
- Depletion of muscle glycogen deposits.
- Muscle damage.
- Stress and mental fatigue.

Therefore, the entire recovery process should aim to meet the demands of the athlete in the four mentioned factors, combined with what was previously discussed regarding the team's tactical-strategic issues.

Fatigue Recovery Strategies in Team Sports

1) **Rehydration:** a 2% body weight decrease leads to a loss in performance, and 5% can cause cognitive disorders (Maughan, R. J., Merson, S. J., Broad, N. P., & Shirreffs, S. M., 2004). Immediately after exercise, athletes should drink enough carbohydrate drinks to replace fluid losses caused by exercise. These drinks should contain sodium and be close to between one and a half and twice the weight lost through sweat. Likewise, alcoholic drinks and coffee are discouraged in these periods due to their diuretic effect. The following chart is a comparison of the hydration index of 13 commercially available drinks.

Figure 10: Hydration Index of 13 Commercially Available Drinks



Source: Maughan et. al., 2016.

2) **Appropriate Nutritional Strategies:** consumption of high glycemic index carbohydrates and high biological value protein is key to replenishing glycogen deposits and optimizing muscle repair after damage induced by intense exercise. In addition, these should be consumed before the end of the competition. Furthermore, it is important to incorporate food intake containing high doses of Omega 3 fatty acids and antioxidants (Nédélec, M., 2013).

3) **Sleep (Quality and Quantity):** Sleep is an essential part of an athlete's recovery process, because sleep disturbances negatively affect this process. Sleep is not only an important factor in muscle recovery, but also for mental fatigue. There are several recommendations such as: sleeping in a quiet environment, maintaining a stable temperature of approximately 18°C, wearing comfortable clothing, maintaining a set routine, avoiding using tablets or phones with bright screens in bed, resting at least seven hours at night, ensuring the room is dark enough, listening to quiet music and regulating the consumption of alcohol or caffeine, which can have a diuretic effect and can disrupt sleep (Nédélec, M., 2013).

4) **Cold Water Immersion** at a temperature between 9°C and 10°C for 10 to 20 minutes seems to be a useful strategy to quickly regain strength levels and reduce acute inflammation after the match. The benefits of this approach are more related to the temperature of the water than with hydrostatic pressure. Some research shows that 15 minutes in water at approximately 15°C reduces blood flow to the legs and arms, redirecting it from the periphery to the core and thereby increasing venous return and heart efficiency. It also limits acute inflammation caused by muscle damage and has a short analgesic effect due to the decrease in nerve conduction speed, the activity of muscle spindles, myotatic reflex and muscle spasms (Nédélec, M., 2013).

5) **Massage and Other Measures:** massage is a widely used tool despite the fact that its effectiveness on muscle function is unclear. It seems that the psychological effect of a sense of well-being in the individual is more important than the actual physiological effects (Bishop, D., 2003).

6) **Electrostimulation** and other treatments such as active recovery, passive stretching, and compression garments still lack scientific evidence to support their use, although this does not mean they are necessarily useless in recovery. Perhaps the protocols carried out in scientific literature are not ideal for evaluating these treatments or perhaps it is their placebo effect that increases the athlete's sense of well-being; either way, they should not be discarded (Nédélec, M., 2013).

References

Ascensão, A., Rebelo, A., Oliveira, E., Marques, F., Pereira, L., & Magalhães, J. (2008). Biochemical impact of a soccer match—analysis of oxidative stress and muscle damage markers throughout recovery (Author's translation). *Clinical biochemistry*, *41*(10), 841-851.

Andersson, H. M., Raastad, T., Nilsson, J., Paulsen, G., Garthe, I., & Kadi, F. (2008). Neuromuscular fatigue and recovery in elite female soccer: effects of active recovery (Author's translation). *Medicine & Science in Sports & Exercise*, *40*(2), 372-380.

Bagnara, I. (2011). El desarrollo tecnológico en las actividades físicas y el deporte. *EFDeportes.com, Digital Magazine*, *16*(159). Buenos Aires. Retrieved from http://www.efdeportes.com

Baker, D., Wilson, G., & Carlyon, R. (1994). Periodization: The Effect on Strength of Manipulating Volume and Intensity (Author's translation). *The Journal of Strength & Conditioning Research*, *8*(4), 235-242.

Balsalobre-Fernández, C., Glaister, M., & Lockey, R. A. (2015). The validity and reliability of an iPhone app for measuring vertical jump performance (Author's translation). *Journal of sports sciences*, *33*(15), 1574-1579.

Bengtsson, H., Ekstrand, J., & Hägglund, M. (2013). Muscle injury rates in professional football increase with fixture congestion: an 11-year follow-up of the UEFA Champions League injury study (Author's translation). *British journal of sports medicine*, *47*(12), 743-747.

Bishop, P. A., Jones, E., & Woods, A. K. (2008). Recovery from training: a brief review: brief review. (Author's translation) *The Journal of Strength & Conditioning Research*, *22*(3), 1015-1024.

Bishop, D. (2003). Warm up I. (Author's translation) *Sports medicine*, *33*(6), 439-454.

Bliss, L. S., & Teeple, P. (2005). Core stability: the centerpiece of any training program (Author's translation). *Current sports medicine reports*, *4*(3), 179-183.

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

Boyd, L. J., Ball, K., & Aughey, R. J. (2011). The reliability of MinimaxX accelerometers for measuring physical activity in Australian football

(Author's translation). *International Journal of Sports & Physiology Performance*, *6*(3), 311-321.

Calder, A. W., Chilibeck, P. D., Webber, C. E., & Sale, D. G. (1994). Comparison of whole and split weight training routines in young women (Author's translation). Canadian Journal of Applied Physiology, 19(2), 185-199.

Candow, D. G., & Burke, D. G. (2007). Effect of short-term equal-volume resistance training with different workout frequency on muscle mass and strength in untrained men and women (Author's translation). *The Journal of Strength & Conditioning Research*, *21*(1), 204-207.

Cappozzo, A., Felici, F., Figura, F., & Gazzani, F. (1985). Lumbar spine loading during half-squat exercises (Author's translation). *Medicine and science in sports and exercise*, *17*(5), 613-620.

Cormie, P., McBride, J. M., & McCaulley, G. O. (2009). Power-time, force-time, and velocity-time curve analysis of the countermovement jump: impact of training (Author's translation). *The Journal of Strength & Conditioning Research*, *23*(1), 177-186.

Coutts, A. J., & Duffield, R. (2010). Validity and reliability of GPS devices for measuring movement demands of team sports (Author's translation). *Journal of science and Medicine in Sport*, *13*(1), 133-135.

Cummins, C., Orr, R., O'Connor, H., & West, C. (2013). Global positioning systems (GPS) and microtechnology sensors in team sports: a systematic review (Author's translation). *Sports Medicine*, *43*(10), 1025-1042.

DeMichele, P. L., Pollock, M. L., Graves, J. E., Foster, D. N., Carpenter, D., Garzarella, L., & Fulton, M. (1997). Isometric torso rotation strength: effect of training frequency on its development (Author's translation). *Archives of physical medicine and rehabilitation*, *78*(1), 64-69.

Deminice, R., Sicchieri, T., Mialich, M. S., Milani, F., Ovidio, P. P., & Jordao, A. A. (2011). Oxidative stress biomarker responses to an acute session of hypertrophy-resistance traditional interval training and circuit training (Author's translation). *The Journal of Strength & Conditioning Researc*h, *25*(3), 798-804.

Dupont, G., Nedelec, M., McCall, A., McCormack, D., Berthoin, S., & Wisløff, U. (2010). Effect of 2 soccer matches in a week on physical performance and injury rate (Author's translation). *The American journal of sports medicine*, *38*(9), 1752-1758.

Ekstrand, J., Waldén, M., & Hägglund, M. (2004). A congested football calendar and the wellbeing of players: correlation between match exposure of European footballers before the World Cup 2002 and their injuries and performances during that World Cup (Author's translation). *British journal of sports medicine*, 38(4), 493-497.

Escamilla, R. F., & Andrews, J. R. (2009). Shoulder muscle recruitment patterns and related biomechanics during upper extremity sports (Author's translation). *Sports medicine*, *39*(7), 569-590.

Faries, M. D., & Greenwood, M. (2007). Core Training: Stabilizing the Confusion (Author's translation). *Strength & Conditioning Journal*, *29*(2), 10-25.

Feigenbaum, M. S., & Pollock, M. L. (1997). Strength training: rationale for current guidelines for adult fitness programs (Author's translation). *The physician and sportsmedicine*, *25*(2), 44-64.

Fleck, S. J., & Kraemer, W. (2014). *Designing Resistance Training Programs* (4th ed) (Author's translation). USA: Human Kinetics.

Fredericson, M., & Moore, T. (2005). Core stabilization training for middle-and long-distance runners (Author's translation). *New studies in athletics*, *20*(1), 25-37.

Gabbett, T. J. (2008). Do skill-based conditioning games offer a specific training stimulus for junior elite volleyball players? (Author's translation). *The Journal of Strength & Conditioning Research*, *22*(2), 509-517.

González, J. C., Domínguez, C. G., y Cepeda, N. T. (2009). Recuperación en balonmano de alto nivel. *Revista de Ciencias del Deporte [Sports Science Magazine]*, *5*(1), 45-54.

González-Badillo, J. J., Gorostiaga, E. M., Arellano, R., & Izquierdo, M. (2005). Moderate resistance training volume produces more favorable strength gains than high or low volumes during a short-term training cycle (Author's translation). *The Journal of Strength & Conditioning Research*, *19*(3), 689-697.

Graves, J. E., Pollock, M. L., Foster, D., Leggett, S. H., Carpenter, D. M., Vuoso, R., & Jones, A. (1990). Effect of training frequency and specificity on isometric lumbar extension strength (Author's translation). *Spine*, *15*(6), 504-509.

Hagins, M., Adler, K., Cash, M., Daugherty, J., & Mitrani, G. (1999). Effects of practice on the ability to perform lumbar stabilization exercises

(Author's translation). *Journal of Orthopaedic & Sports physical therapy*, *29*(9), 546-555.

Halson, S. L. (2013). Recovery techniques for athletes (Author's translation). *Sports Science Exchange*, *26*(120), 1-6.

Harris, N. K., Cronin, J., Taylor, K. L., Boris, J., & Sheppard, J. (2010). Understanding position transducer technology for strength and conditioning practitioners (Author's translation). *Strength & Conditioning Journal*, *32*(4), 66-79.

Herman, K., Barton, C., Malliaras, P., & Morrissey, D. (2012). The effectiveness of neuromuscular warm-up strategies that require no additional equipment, for preventing lower limb injuries during sports participation: a systematic review (Author's translation). *BMC medicine*, *10*(1), 1.

Hibbs, A. E., Thompson, K. G., French, D., Wrigley, A., & Spears, I. (2008). Optimizing *performance* by improving core stability and core strength (Author's translation). *Sports medicine*, *38*(12), 995-1008.

Hodgson, M., Docherty, D., & Robbins, D. (2005). Post-activation potentiation (Author's translation). *Sports Medicine*, *35*(7), 585-595.

[Untitled image of GPS 1 systems]. (Undated). Retrieved from http://www.marcaenzona.com/detalle.php?id_news=3557

[Untitled image of GPS 2 systems]. (Undated). Retrieved from http://www.techflow.co/firstbeat-the-heartbeat-behind-2016-mvp-steph-curry-and-gsw/

[Untitled image of VBT]. (Undated). Retrieved from: http://www.innervations.com/products/ballistic-measurement-system/linear-position-transducer/-.

[Untitled image of accelerometer]. (Undated). Retrieved from: http://goo.gl/OjjZ7l. http://www.trainwithpush.com/portal/-.

Kirkendall, D. (2014). 10 FAQ about warm-up & injury prevention in football (Author's translation). Aspetar *Sports Medicine Journal*. Retrieved from http://www.aspetar.com/journal/viewarticle.aspx?id=27

Konin, J. G., Beil, N., & Werner, G. (2003). Facilitating the serape effect to enhance extremity force production (Author's translation). *Athletic Therapy Today*, *8*(2), 54-56.

Lago Peñas, C. Martín Acero, R., Seirul-lo Vargas, F., Alcalde, J., & Hernández Moreno, J. (2011). La relación de la fatiga con el rendimiento en los deportes de equipo. *Revista de Entrenamiento Deportivo*, *25*(04), 05-15.

Leetun, D. T., Ireland, M. L., Willson, J. D., Ballantyne, B. T., & Davis, I. M. (2004). Core stability measures as risk factors for lower extremity injury in athletes (Author's translation). *Medicine & Science in Sports & Exercise*, *36*(6), 926-934.

Mann, J. B., Ivey, P. A., & Sayers, S. P. (2015). Velocity-Based Training in Football (Author's translation). *Strength & Conditioning Journal*, *37*(6), 52-57.

Maughan, R. J., Merson, S. J., Broad, N. P., & Shirreffs, S. M. (2004). Fluid and electrolyte intake and loss in elite soccer players during training (Author's translation). International journal of sport nutrition and exercise metabolism, 14(1), 333-346.

Maughan, R. J., Watson, P., Cordery, P. A., Walsh, N. P., Oliver, S. J., Dolci, A., & Galloway, S. D. (2015). A randomized trial to assess the potential of different beverages to affect hydration status: development of a beverage hydration index (Author's translation). *The American journal of clinical nutrition*. Retrieved from http://ajcn.nutrition.org/content/early/2015/12/23/ajcn.115.114769.abstract.

McGill, S. (2010). Core training: Evidence translating to better performance and injury prevention (Author's translation). *Strength & Conditioning Journal*, *32*(3), 33-46.

McGowan, C. J., Pyne, D. B., Thompson, K. G., & Rattray, B. (2015). Warm-Up Strategies for Sport and Exercise: Mechanisms and Applications (Author's translation). *Sports Medicine*, *45*(11), 1523-1546.

Miranda, H., Fleck, S. J., Simão, R., Barreto, A. C., Dantas, E. H., & Novaes, J. (2007). Effect of two different rest period lengths on the number of reps performed during resistance training (Author's translation). *The Journal of Strength & Conditioning Research*, *21*(4), 1032-1036.

Montgomery, P. G., Pyne, D. B., Hopkins, W. G., Dorman, J. C., Cook, K., & Minahan, C. L. (2008). The effect of recovery strategies on physical performance and cumulative fatigue in competitive basketball (Author's translation). *Journal of sports sciences*, *26*(11), 1135-1145.

Nédélec, M., McCall, A., Carling, C., Legall, F., Berthoin, S., & Dupont, G. (2012). Recovery in Soccer (Author's translation). *Sports Medicine*, *42*(12), 997-1015.

Nédélec, M., McCall, A., Carling, C., Legall, F., Berthoin, S., & Dupont, G. (2013). Recovery in Soccer (Author's translation). *Sports Medicine*, *43*(1), 9-22.

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., Alvar, B. A., Burkett, L. N., & Ball, S. D. (2003). A meta-analysis to determine the dose response for strength development (Author's translation). *Medicine and science in sports and exercise*, *35*(3), 456-464.

Santana, J. C., McGill, S. M., & Brown, L. E. (2015). Anterior and Posterior Serape: The Rotational Core (Author's translation). *Strength & Conditioning Journal*, *37*(5), 8-13.

Seitz, L. B., de Villarreal, E. S., & Haff, G. G. (2014). The temporal profile of postactivation potentiation is related to strength level (Author's translation). *The Journal of Strength & Conditioning Research*, *28*(3), 706-715.

Seitz, L. B., Trajano, G. S., & Haff, G. G. (2014). The back squat and the power clean: elicitation of different degrees of potentiation (Author's translation). *International Journal of Sports & Physiology Performance*, *9*(4), 643-9.

Seitz, L. B., & Haff, G. G. (2016). Factors modulating post-activation potentiation of jump, sprint, throw, and upper-body ballistic performances: a systematic review with meta-analysis (Author's translation). Sports Medicine, 46(2), 231-240.

Stone, M. H., O'Bryant, H. S., Schilling, B. K., Johnson, R. L., Pierce, K. C., Haff, G. G., & Koch, A. J. (1999a). Periodization: Effects Of Manipulating Volume And Intensity. Part 1 (Author's translation). *Strength & Conditioning Journal*, *21*(2), 56.

Stone, M. H., O'Bryant, H. S., Schilling, B. K., Johnson, R. L., Pierce, K. C., Haff, G. G., & Koch, A. J. (1999b). Periodization: Effects of Manipulating Volume and Intensity. Part 2 (Author's translation). *Strength & Conditioning Journal*, *21*(3), 54.

Tan, B. (1999). Manipulating Resistance Training Program Variables to Optimize Maximum Strength in Men: A Review (Author's translation). *The Journal of Strength & Conditioning Research*, *13*(3), 289-304.

Terrados, N., Calleja-González, J., & Schelling, X. (2011). Bases fisiológicas comunes para deportes de equipo. *Revista Andaluza de Medicina del Deporte*, *4*(2), 84-88.

Tillin, M. N. A., & Bishop, D. (2009). Factors modulating post-activation potentiation and its effect on performance of subsequent explosive activities (Author's translation). *Sports medicine*, *39*(2), 147-166.

Willardson, J. M., & Burkett, L. N. (2008). The effect of different rest intervals between sets on volume components and strength gains (Author's translation). *The Journal of Strength & Conditioning Research*, *22*(1), 146-152.

Willardson, J. M. (2006). A brief review: factors affecting the length of the rest interval between resistance exercise sets (Author's translation). *The Journal of Strength & Conditioning Research*, *20*(4), 978-984.

Wilson, J. D., Dougherty, C. P., Ireland, M. L., & Davis, I. M. (2005). Core stability and its relationship to lower extremity function and injury (Author's translation). *Journal of the American Academy of Orthopaedic Surgeons, 13*(5), 316-325.

Wilson, J. M., Duncan, N. M., Marin, P. J., Brown, L. E., Loenneke, J. P., Wilson, S. M. & Ugrinowitsch, C. (2013). Meta-analysis of postactivation potentiation and power: effects of conditioning activity, volume, gender, rest periods, and training status (Author's translation). *The Journal of Strength & Conditioning Research*, *27*(3), 854-859.

Woods, K., Bishop, P., & Jones, E. (2007). Warm-up and stretching in the prevention of muscular injury (Author's translation). *Sports Medicine*, *37*(12), 1089-1099.

Zois, J., Bishop, D. J., Ball, K., & Aughey, R. J. (2011). High-intensity warm-ups elicit superior performance to a current soccer warm-up routine (Author's translation). *Journal of science and medicine in sport*, *14*(6), 522-528.